INSTRUMENTS

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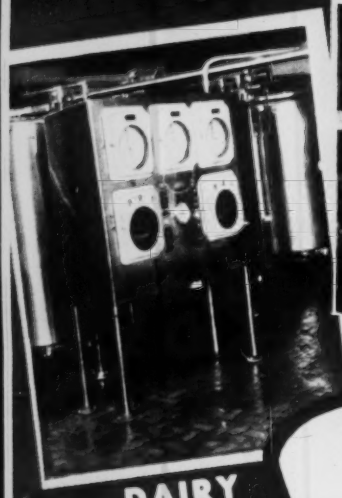
DECEMBER

1937

NUMBER 12



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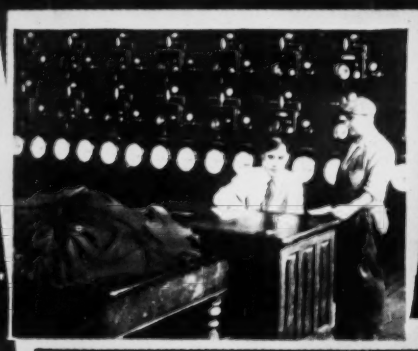

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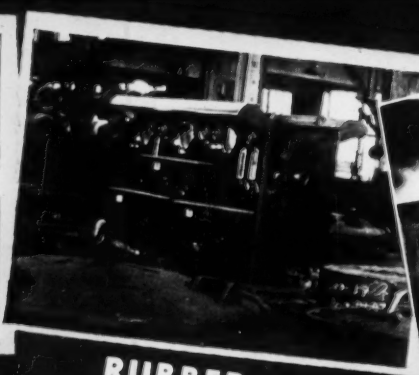

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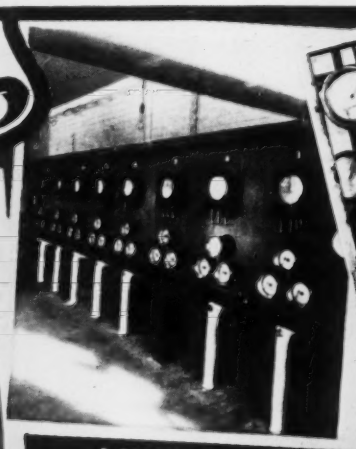

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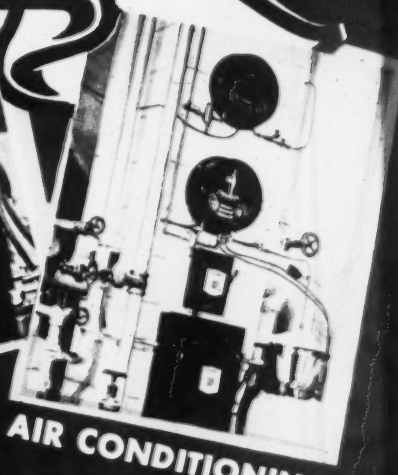

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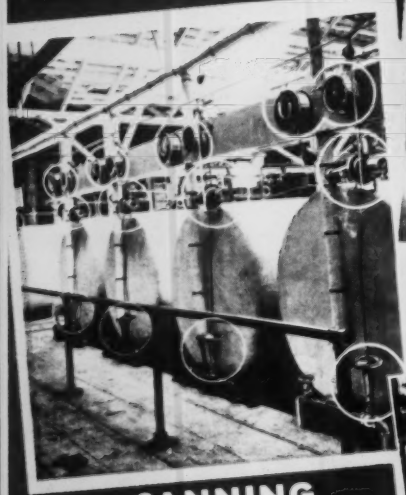

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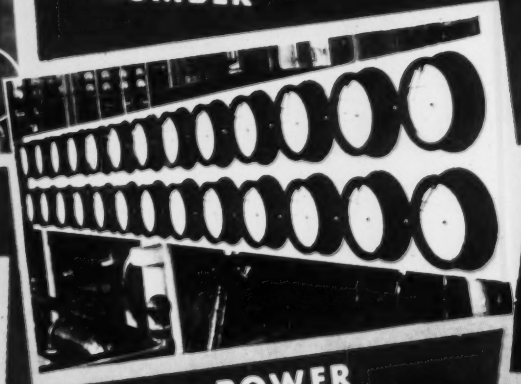

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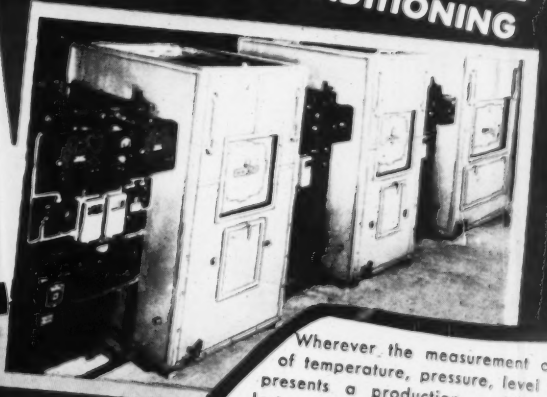

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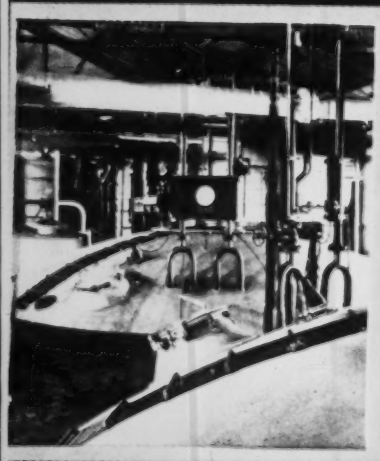

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Wherever the measurement or control of temperature, pressure, level or flow presents a production problem, TAG Instruments offer certain and economical solution. TAG Engineers have reduced these principles to practice and keep production on-the-move with robust plant Instruments that diminish waste through economies in power, processing time and materials while contributing to product uniformity and improvement.

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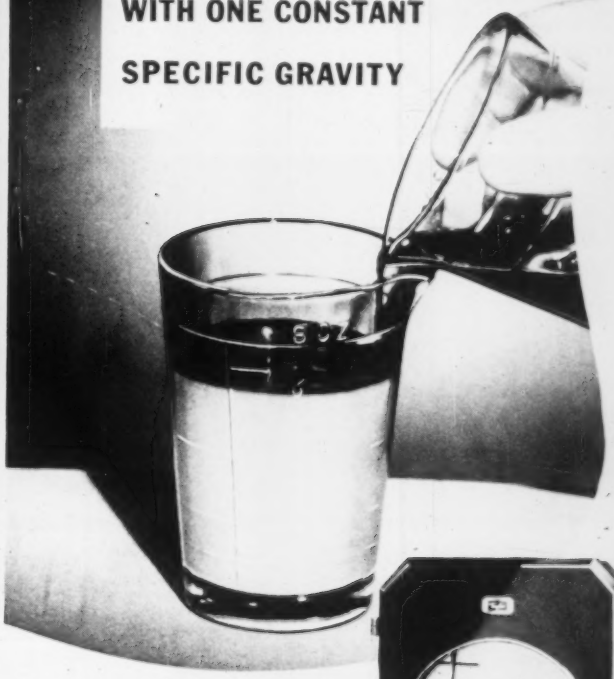
WHEN YOU HAVE...

2 LIQUIDS EACH WITH A DIFFERENT SPECIFIC GRAVITY

AND YOU WANT...

A MIXTURE OF BOTH, WITH ONE CONSTANT SPECIFIC GRAVITY



Taylor offers an automatic method of regulating that constant. Also accurate indicating and recording flow instruments to give a measure of different specific gravities

WHEN it is desirable in a process that two liquids used in it enter the process with one specific gravity—

You can automatically control the flow of the two liquids with Taylor Flow Controllers so that the liquids give a mixture with the specific gravity required.

It may be a combination of acid and water to a constant; or water and a concentrated brine; or two oils. It may be a case of diluting caustics. You can substitute a Taylor Controller for the use of a hydrometer and the adjustment of hand valves. The application of an accurate automatic flow instrument replaces another manual operation.

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Taylor

Indicating Recording Controlling

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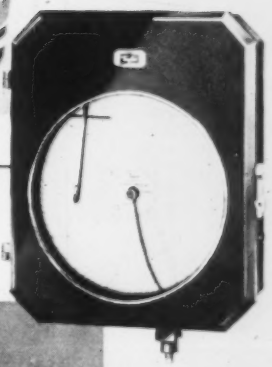
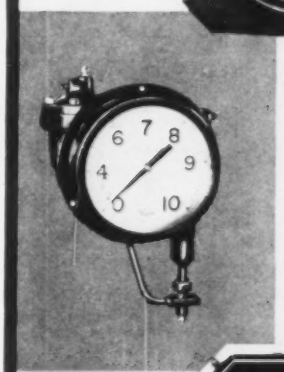
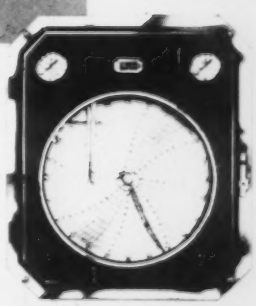




(*Above*) Taylor Flow Recorder for liquids, or for gases and steam under constant pressure

(*Left*) Taylor Dial Type Flow Indicator for liquids or for gases and steam under constant pressure



(*Right*) Taylor Fulscope Recording Flow Controller for liquids, or for gases and steam under constant pressure. Two-pen type for differential pressure.

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

Co-author seventeen years ago of the Bureau of Standards' "Pyrometric Practice" which is a standard text today, C. O. Fairchild ought to know his degrees and Btu's; and when he discloses that a Frenchman's invention of forty years ago has great possibilities today, you can rest assured that this "forgotten" method will soon benefit many industries. Page 305.

Westinghouse dedicated "The World's Most Modern Motor Aisle" last month, and your editor started visiting it but stopped when he came to the testing department: a chance to get an article from Chief Tester Haley. Page 306.

As we go to press, the National Bureau of Standards celebrates the thirtieth anniversary of its service to America—a service without parallel in all the world. Accuracies of 0.1% are "gross measurements" to our good friends in the Bureau, but when this order of accuracy is required in measuring fluid flow during intervals as short as 20 seconds, even these Priests of Precision have to work out a new solution—reported in Morey's article, page 308.

In his serial on hardness measurements, Professor Williams continues his fascinating discussion of modern scratch methods. Page 311.

Ralph Batcher had discussed Automotive applications of the cathode-ray oscillograph last March, but he adds a few recent notes in this issue. Page 313.

Surprising in variety and offering many practical possibilities are the solutions and discussions of the October "Forum" problem. Page 314.

THE FRONT COVER

shows the final test of a motor on the conveyor line at Westinghouse. See Haley's article, page 306.

THE COUNTER READS

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and thereby registers the end of the tenth year of *Instruments'* service to users of measurement and control devices—to all of whom we wish a Merry Christmas and Happy New Year.

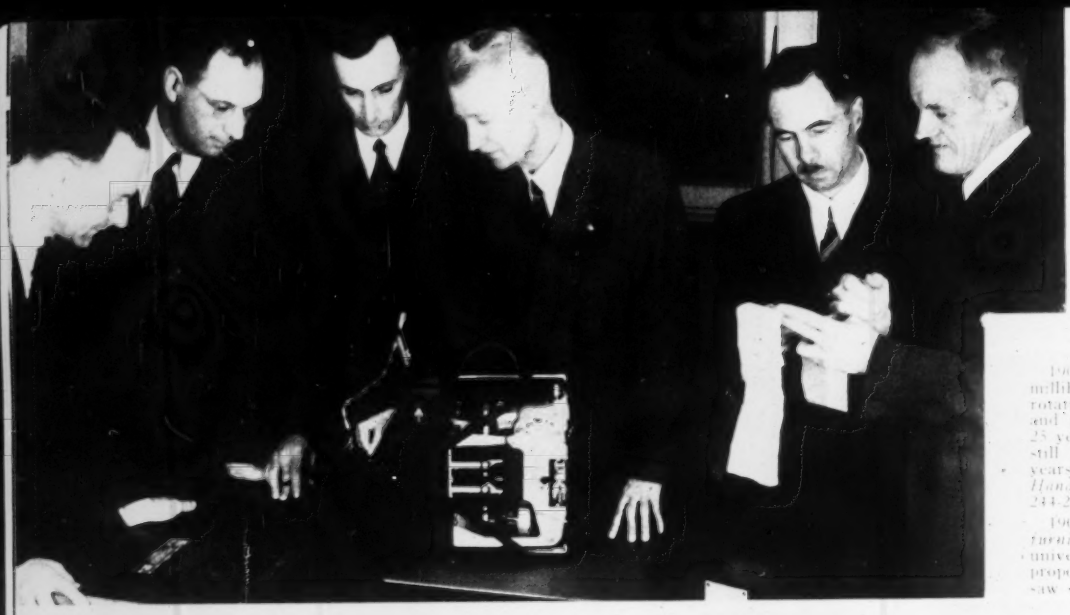
METER ALL COSTS!

IT seems to be the majority opinion among industrial executives that costs of raw materials and of labor will continue to go up. If all other prices were to rise at exactly the same rate, there would not necessarily be any distressing dislocation of American industries. But history shows that "all other prices" do not rise at exactly the same rates; and every vendor of goods and of public services such as transportation or power knows that he cannot or may not boost his prices or rates in time to safeguard his profits. Even if some duly-enacted law or some Board-written regulation does not forbid him to up his prices in exact relation to his costs, he knows that such action would cut him off from many of his potential customers—the many whose purchasing power likewise lags.

He knows, therefore, that if he is to stay in business he must cut down *unit production costs* drastically, by such methods as have enabled Henry Ford to raise wages and to lower selling prices. These methods aren't mysterious; and we need not even summarize them. What we aim to do is simply to remind our readers that the first step is to ascertain, to analyze, to determine quantitatively instead of guesstimating—in short, *to measure*—and (without boring you with our oft-repeated recommendations) to call your particular attention to a class of measuring devices which in many cases deserve your first consideration. We refer to the humble domestic type meters: water meters, gas meters, steam meters, and watthour meters. Yes, we've mentioned them before, but we neglected to emphasize that domestic type meters are so inexpensive that there should be one not only for each and every department but one on almost every piece of equipment; they are so accurate nowadays that . . . well, not long ago we saw a domestic water meter used for heat-loss determination in an acceptance test of a $100,000 generator!

The basis of low-unit-cost mass production is power. Wherever power costs exceed labor costs, power-saving is more important than labor-saving. "But the P.D. won't okay my requisition for graphics on all my machines." They'll okay watthour meters; and when the big boss sees how you spot some power wastes with them, he'll get you your recorders, your demand-limiting devices and your other modern instrumentation equipment!

In plants purchasing power the chief electrician can, by sub-metering, make his department show profits to the big boss.



BUREAU'S INSIDE STAFF STUDIES KNOPP'S LATEST

(Left to right) Albert, Hill, Schneider, Knopp, MacIntyre and Lindbladd examine his power factor attachment. Outside-inspection-boss Chamberlin was absent then, but is "present" here.

1905—*Meter-testing set:* Together with millihour watch replaces to a large extent the rotating test meter, by reason of its simplicity and permanence of calibration. Used for some 25 years almost exclusively in PG&E Co. and is still being used in several divisions after 30 years. Refs. *Electrical World*, July 27, 1907; *Handbook for Electrical Metermen*, pages 243-244-245.

1906—*Method of frequency regulation to furnish time to company customers:* Now universally adopted all over the world. First proposed by Knopp in 1906, but company then saw serious objections in that line interruptions would be shown up. Ref. *Pacific Service Magazine* (P. G. & E. publ.), Oct. 2, 1909, page 91.

1907—*Arc circuit switch:* Designed to switch out, by means of the series arc circuit, isolated multiple circuits, such as out-of-the-way station lights. Did away with need of installing line switches (then requiring considerable attention). Made from old series arc lamps; inexpensive; served until series arc circuits were abandoned.

1910—*Multirange a-c. line current testing set:* Enabled engineers and line crews to measure large and small line currents without opening circuit where load surveys are made and transformer circuits have to be balanced. Used extensively in its original form in all divisions of PG&E Co. and hundreds of other companies; has been copied by a number of manufacturers.

1911—*Millihour pendulum and centihour timer:* Built to take care of accurate timing and calibration work on watthour meters and portable standards. Gives time in decimals of an hour, like the millihour stop watch, but more accurate; for laboratory and meter shops. Used up to this day; saves labor; is considered indispensable. Copied in the East. Pendulum ref. *Pacific Gas & Electric Co. Magazine*, Sept. 1912. Centihour Timer ref. *National Electric Light Ass'n Committee Report, Technical Not Section*, 1924.

1912—*D-c. line current testing set:* For measuring direct currents on cables and railway feeders without opening the circuit. Based on a fundamentally new principle. Original set still in use in San Francisco; many other elsewhere. Refs. *N.E.L.A. Bulletin*, Dec. 1912; *Electrical World*, May 1, 1926.

1913—*"Tweaksetbon meter", method for absolute calibration of current transformers:* De-

INSTRUMENTS' READERS AT WORK

No. 29—OTTO A. KNOPP, Chief
No. 30—W. N. LINDBLADD, Assistant Chief
No. 31—N. M. ALBERT, Stds. & Maint'ce Div. Head
No. 32—E. J. CHAMBERLIN, Inspection Div. Head
No. 33—G. L. HILL, Engineering Invest'n Div. Head
No. 34—A. D. MacINTYRE, Materials Test Div. Head
No. 35—W. R. SCHNEIDER, Electrolysis Div. Head

Bureau of Tests & Inspection, Pacific Gas & Electric Co., Emeryville, Calif.

B. M. T. BEHAR

IN reporting other visits to "Readers at Work"—especially in the case of charter subscribers—we have proudly quoted their statements that *Instruments* is their indispensable source of information and inspiration. We heard many such statements that day we spent in Emeryville, and their sincerity was borne out by well-worn copies of *Instruments* on desks in various departments, but years of correspondence with Knopp had made us feel that at last there like him who are the primary sources of information and inspiration and we became convinced of it that day in Emeryville.

Born in Berlin August 24, 1877, Knopp studied engineering at the Technische Hochschule at Charlottenburg and at Coethen. He started working at the Bergmann electrical works in 1899, then in the aeronautical department of the Royal Prussian Meteorological Institute, his instrument work quickly winning him a reputation heard of in America, to which he came in December 1901.

After three months at the Blue Hills Aeronautical Observatory of Harvard University, during which he improved various devices and sent kites 20,000 feet up with recorders) he went to the General Electric Company at Schenectady at the recommendation of the late Elihu Thompson. After a year there he went to the Pacific Coast, again at the advice of Dr. Thompson. "The rest is history."—a history with which we could fill a dozen pages, and which even in brief telegraphic style we are compelled to print in small type. And we are merely giving the reader a chronology of *things*, which could be supplemented by an inspiring compendium of human-interest episodes in the life of a man who has already become a beloved institution.

1903—*Multirange rotating standard test meter set, and the "120-Hour Volt-Ampere Meter":* Forerunner of the modern rotating standards for testing watthour meters. Used by Oakland Gas, Light and Heat Co. and PG&E Co. for several years. It had a telephone attachment; operator counted the standard revs by ear and the test revs by eye. Method later known as "ear and eye" method and used extensively in East. Ref. *Electrical World*, July 27, 1907.

1904—*Millihour stop watch* for timing watthour meters; minimized calculation for deriving load on meter; method enabled meter tester to read correction factor of meter directly off watch without calculations. Ref. *Handbook for Electrical Metermen*, 4th edition, pages 245-246.

loped when an important efficiency test of a w steam turbine had to be made and a conversy arose regarding accuracy of some current transformers. Solved the problem of calibrating these current transformers without a ference standard. Used for many years in G&E Co., also by Bureau of Standards and stern labs. Refs. *Electrical World*, Jan. 8, 916; *NELA Bulletin*, Nov. 1916.

1914—*D-c. transformer:* Built to measure and cord direct current without opening the circuit. Used in PG&E Co., later by a number of her companies, for survey work on d-c. networks. Fundamentally new principle, similar to above d-c. line current testing set. Called a transformer because mechanically analogous to well-known a-c. transformer. Refs. *Journal of Electricity, Power & Gas*, April 18, 1914; *Electrical World*, Oct. 2, 1915.

1915—*Straight-line watthour meter:* Intention, to eliminate losses due to under-registration on overloads. A so-called curve straightening device made commercially-produced meters perform accurately on loads up to 300%, instead of dropping off 12% to 15% in registration. This focused the industry's attention and resulted 8 or 10 years later in manufacturers developing modern straight-line meter which has both increased power companies' revenue and decreased meter production costs by eliminating many sizes of meters. Ref. *Journal of Electricity*, April 1919.

1916—*Calibrating method:* Makes use of multirange precision current transformers for calibrating commercial ammeters, wattmeters, ampere-hour and watthour meters. Did away with multiplicity of primary standards and need of keeping all these standards in calibration. Made it possible to obtain much closer agreement in calibration of numerous multirange portable standards in PG&E Co. and hence more accurate performance over whole system. Ref. *Electrical World*, May 1, 1920.

1917—*Precision multirange instrument transformer and multirange ammeters:* Multirange precision instrument transformer standards can be accurately calibrated without reference to other standards; need not be sent to Bureau of Standards for accurate calibration. Out of this development sprang the multirange ammeter having seven ranges all responding to one scale and calibration; no need to supply a tester with a large number of instruments to do this work. These instruments are used in large numbers all over the U. S. Refs. *Electrical World*, May 1, 1920; *Electrical Engineering*, May 1936, page 480.

1918—*Duplex device for demand metering:* Made it possible to obtain combined coincident demand of two meters on one demand meter. Has become popular in PG&E Co., both for indicating and recording demand. Adopted by G.E., device is used in hundreds of thousands of meters. Ref. U. S. Patent No. 1,477,367.

1919—*Current transformer compensating methods:* Proposed for more accurate compensation of PG&E Co.'s own current transformer standards; resulted in more accurate performance of these standards; were adopted by several manufacturers. Refs.: U. S. Patents No. 1,399,908 and No. 1,550,960.

1920—*Combination torsion head indicating type wattmeter:* Was built and used as a detector wattmeter in calibrating instrument transformers by a special indicating test method. Instrument and method have speeded up such calibrations and improved accuracy. Instrument is being commercial produced. Ref. *Electrical World*, Feb. 19, 1927, page 407.

STANDARDIZATION AND MAINTENANCE DIVISION—Corner of standardizing room.

1921—*Multiplex device for demand metering:* For obtaining combined coincident demand of loads of a large number of watthour meters. Many in constant use. Marketed in recent years by G.E. and by Electrical Facilities Inc. Refs. *Proceedings P.C.G.A.*, 1924; *Electrical World*, March 19, 1927, page 609.

1922—*Totalizing demand recorder:* Built from standard instruments to record total demand obtained by the multiple device or duplex device. Useful in graphing demand of large customers. A large number in constant use. Ref. *Electrical World*, March 19, 1927, page 609.

OTTO A. KNOPP

1923—*Current transformer testing equipment:* Provided the various meter labs of PG&E Co. with a convenient current transformer testing outfit by making use of the self-calibrating precision multirange current transformer designed in 1917, connected in such a way that a relatively non-experienced operator can test any size of current transformer by throwing a single switch corresponding to the size of the transformer under test; he thereby obtains automatically the proper load and cuts in the corresponding range of the standard, reading the ratio error on the special detector wattmeter of 1920. By throwing switch he can obtain phase angle of transformer under test. Equipment has been marketed; is used in various meter labs of PG&E Co., in the Standardizing Lab. and by many power companies. Refs. *NELA Meter Committee Report*, June 16, 1925; *Electrical West*, May 15, 1928.

1924—*Potential transformer testing equipment:* For accurate calibration of potential transformers by means of the self-calibrating precision multirange potential transformer of 1917. Makes possible accurate calibration of potential transformers for ratios from 120-14,300/120 on ratio and phase angle using as detector the combination torsion head indicating wattmeter of 1920. Manufactured commercially; used by many power companies. Ref. *Proceedings AIEE*, 1936.

1924—*Constant speed rotating standard:* Made use of the precision multirange current transformer and constituted a convenient multirange rotating test meter which provided also a phantom load for testing, doing away with multiplicity of connections and saving time in testing. Ref. *NELA Meter Committee Serial Report, 1926-1927, Publication No. 267-92.*

1925—*Meter testing equipment:* Built at request of PG&E's Operating Dept to end great variety of inadequate equipments used in various divisions for testing watthour meters. It was designed to provide fool-proof, precise and labor saving apparatus and was found (after trial installations) to be so serviceable and inexpensive that it was quickly adopted by all divisions. Results: saving of time in shop testing; saving in laboratory work by doing away with continuous checking of field standards; increase in accuracy of meters on PG&E system. Various manufacturers are building this equipment, now used by many power companies here and abroad. Refs.: *NELA Serial Report of Meter Committee*, July 1927, *Publication No. 267-92*; *Electrical Engineering*, May 1936.

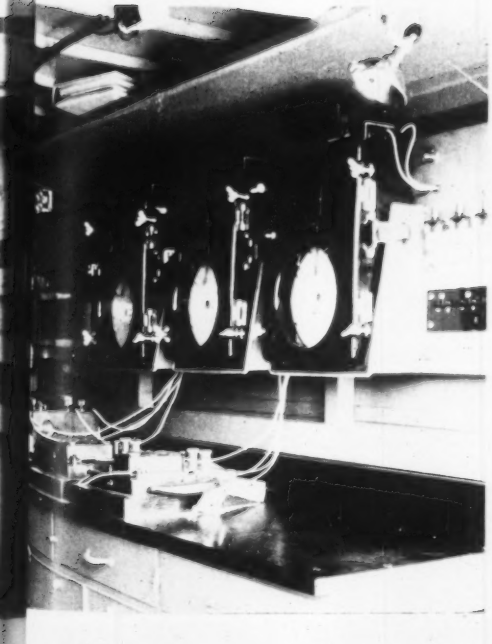
1926—*Large capacity precision current transformer:* Was designed to reduce expense and bulkiness of multirange precision current transformers for large currents. Only one pair of primary current terminals; ranges obtained by taps in secondary, which is wound in a number of sections each uniformly distributed around a ring core; single-turn primary also distributed uniformly around this ring core. Resistance of secondary so proportioned that resistance from a common point to any one tap is proportional to the square of number of turns. Thus all ranges, assuming a zero external burden, have the same ratio and phase angle error. Transformer can be calibrated in itself at extremely high precision by means of the so-called "one to one" method, using 25 to 25 amp instead of 5 to 5 amp for calibrating. Accuracies of 0.002% can be obtained in ratio, and fractions of a minute in phase angle. Refs.: *Electrical West*, May 15, 1928; *Electrical Engineering*, May 1936.

1927—*Precision combination dead weight and indicating gage:* Was built to make accurate hydraulic measurements in connection with efficiency tests on water wheels. It determines a fluctuating hydrostatic pressure to 0.1% by combining dead-weight gage principle with that of indicating gage.

1927—*Load survey equipment:* Developed to simplify equipment and methods for obtaining a complete record of the wattage and power factor on a 3-phase circuit. Instead of customary two recorders (wattmeter and reactive kva meter) one recording wattmeter records wattage and gives indication of power factor every 10 or 20 minutes. By addition of precision multiratio split core transformers and multirange potential transformers, load surveys can be made on small and large load circuits from 480 to 12,000 volts. Ref.: U. S. Patent No. 1,904,020 (applied for Sept. 16, 1927).

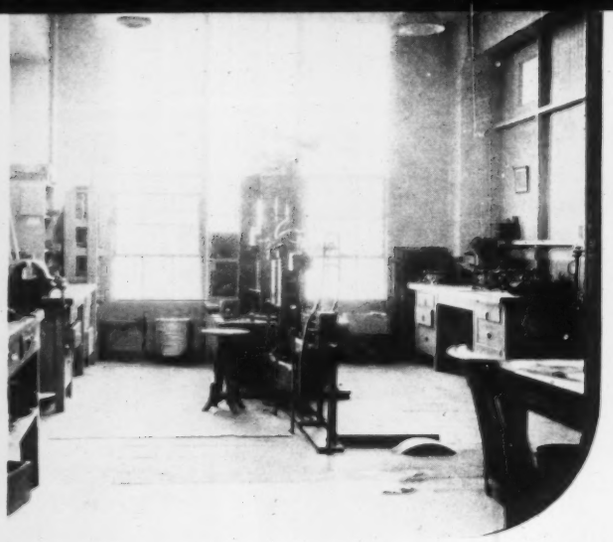
1928—*Phase sequence indicator:* Formerly, errors were frequently made in phasing in polyphase lines, and Company had to pay for injuries to customers' equipment, because existing indicators could not be used by average linemen. Simple, rugged and inexpensive indicator supplied to all line crews on PG&E system has enabled them to make sure of proper phase sequence before cutting in customers' equipment, thus avoiding expensive errors. Ref.: *Electrical World*, March 26, 1927.

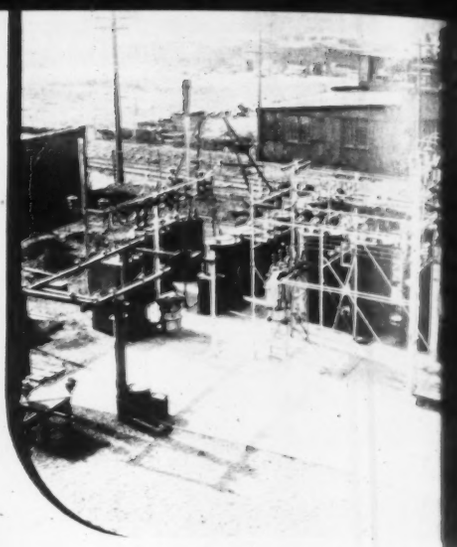
1928—*Electric range hot plate:* Designed to overcome thermal lag of average electric range unit. A section of resistance of unit is shunted by a pair of contacts. These are pulled apart by the expansion of a metallic member as the unit reaches normal working temperature, and an additional resistance cut into circuit. Range unit is not only faster than the standard unit but has much longer life. A large number have been in service for years. Ref.: U. S. Patent

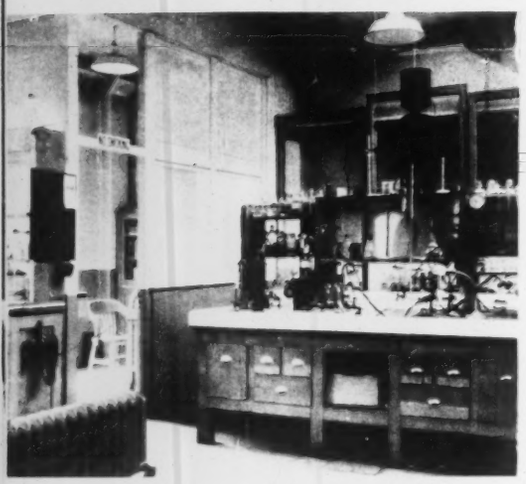


ELECTROLYSIS DIVISION

Interior of one of the electrolysis testing trucks; and test table inside the truck.







MATERIALS TESTING DIVISION. Corner of concrete testing laboratory; corner of physical testing room; a glimpse of the chemical laboratories.

No. [illegible] applied for April 15, 1927) and subsequent.

1931—*The "Thermo-Electric Valve."*: Development of this valve followed tests of those on the market, for use with PG&E's conversion gas installations. Available electrically-operated valves were found to have mechanism subject to failure: motors, reduction gears, relays, solenoids and movable contacts. Knopp adopted an entirely new principle, doing away with all moving parts, motors, solenoid and contacts, and replacing customary "on-and-off" action by the most desirable "throttling" mode. Excellent service record of his invention may foreshadow a new and useful valve construction. Ref.: U. S. Patent No. 1,994,771.

1932—*Method for pipe protection method.*: Advent of natural gas brought into being a tremendous network of high pressure transmission lines and consequent problem of protection against soil corrosion and galvanic currents flowing from between soil areas of different [illegible] section. PG&E's 22" high-pressure [illegible] developed failures after being in the ground only two months. This being the only natural gas supply to San Francisco in 1930, action had to be taken immediately. Under pressure of the great emergency Knopp developed [illegible] pipe protection method. Results: no [illegible] in that time after almost eight years [illegible] installations have been made in PG&E system, saving annually over $100,000. Method [illegible] taken over and put to other uses, saving millions annually.

1933—*Solution to problem of leakproofing [illegible] and space joints in San Francisco*: Primary cause for advent of natural gas into [illegible] city, resulted from the many miles [illegible] and thus opens minute cracks. Extent of [illegible] had been estimated at several [illegible] Knopp's radically new method [illegible] which reacts with the [illegible] recommended. More than [illegible] have been placed in service [illegible] and are permanently [illegible] superior to that of other [illegible] Saves [illegible] to millions. Ref.: U. S. Patent No. 2,033,[illegible]

1933—*Method for [illegible]*: Was made possible by success achieved with

1934—*The Thermo-Electric Valve.*: Development of this valve followed tests of those on the market, for use with PG&E's conversion gas installations. Available electrically-operated valves were found to have mechanism subject to failure: motors, reduction gears, relays, solenoids and movable contacts. Knopp adopted an entirely new principle, doing away with all moving parts, motors, solenoid and contacts, and replacing customary "on-and-off" action by the most desirable "throttling" mode. Excellent service record of his invention may foreshadow a new and useful valve construction. Ref.: U. S. Patent No. 1,994,771.

1933—*Floating control thermostat.*: Developed in connection with the "Floating Gas Control System" to graduate the current supplied to the "Thermo-Electric" gas valve in response to changes in room temperature. Successfully performing in a number of experimental installations. Ref.: U. S. Patent No. 1,994,771 (applied for June 29, 1931).

1934—*Safety pilot or "Pyro Switch".*: Shuts off gas to main burner when pilot flame is blown out by a draft or fails to light by reason of ignition failure. Switching off a current is not done in customary manner by means of contacts which separate, but gradually by changing a resistance from approx. one ohm to several million ohms. This is accomplished by a special tip, made of fire-resistant material which at red heat has negligible resistance; as soon as it cools below red heat it turns into an effective insulator preventing current flow to gas valve. Hundreds performing successfully in experimental service, but patent situation has stopped further developments. Principle of "Pyro Switch" should be useful for other purposes, however, as it permits gradual shutting down of a current without actually breaking the circuit physically. Ref.: U. S. Patent No. 1,977,854 (applied for Dec. 10, 1930).

1935—*Watthour meter jewel bearing.*: In customary design, jewel cup collects dust and retains all material worn off jewel and pivot point, thus accelerating wear and making many meters "slow," causing a loss of revenue to power companies. In Knopp's design the two members, jewel and pivot point, are inverted: jewel on end of shaft and pivot point below jewel. Jewel shaft end is made hollow to store lubricating oil, which is drawn out by capillary action and surface tension into the jewel cup, lubricating the bearing and preventing accumulation of dust or worn-off particles, keeping contact surfaces between pivot point and jewel perfectly clean. More than 30,000 of these jewel bearings recently installed by a number of utilities. Ref.: U. S. Patent No. 2,092,281 (applied for March 6, 1935).

1936—*Electric hot-water range.*: Customary system of electric cooking and water heating requires installation of electric range, hot-water heater, and in many cases a demand controller to prevent both coming on at the same time. Each of these devices takes up floor space and requires ornamental finish and necessary casing and outlet devices. Knopp combined the two or three into one which not only saves initial cost and floor space but also gains startling advantages: saves the tremendous heat losses of ordinary electric range by using these Btu's for heating the water; uses a superior control, that is, rheostatic control. Waste heat of rheostat also absorbed by water. Cooking efficiency approx. 95% compared to approx. 25% in present-day ranges. Oven heat losses (still larger than those of the top unit) can also be made useful to a large extent. Among other advantages are heat acceleration to give speed to the units, reclaiming of heat after cooking process is completed, etc. U. S. Patent applied for Nov. 19, 1934, is to be issued in Jan. 1938.

Now you know why Knopp is called the Edison of the West.

Space limitations preclude publishing biographies of the other distinguished *Instruments* readers in the Bureau, but we can crowd in brief outlines of their functions.

Assistant Chief Lindbladd: The nature of his work can be gaged from the diversity of the Bureau's scope as shown in these pages, and by mentioning that the PG&E Co.'s purchases normally run to forty million dollars a year!

Albert heads the Standards and Maintenance Division which Knopp calls "the heart of the Laboratory," which has three departments (standardization, instrument repair, and shop) and which is used as a training station for the personnel.

MacIntyre heads the Materials Tests Division and Chamberlin the Inspection Division. The former is responsible for testing samples, etc., brought in; the latter for testing materials on manufacturers' premises.

Hill's Division is Engineering Investigations: research to solve operating problems, to select special equipment, or to design it when necessary. Three departments: elec. & thermal; power tests; radio & telephone.

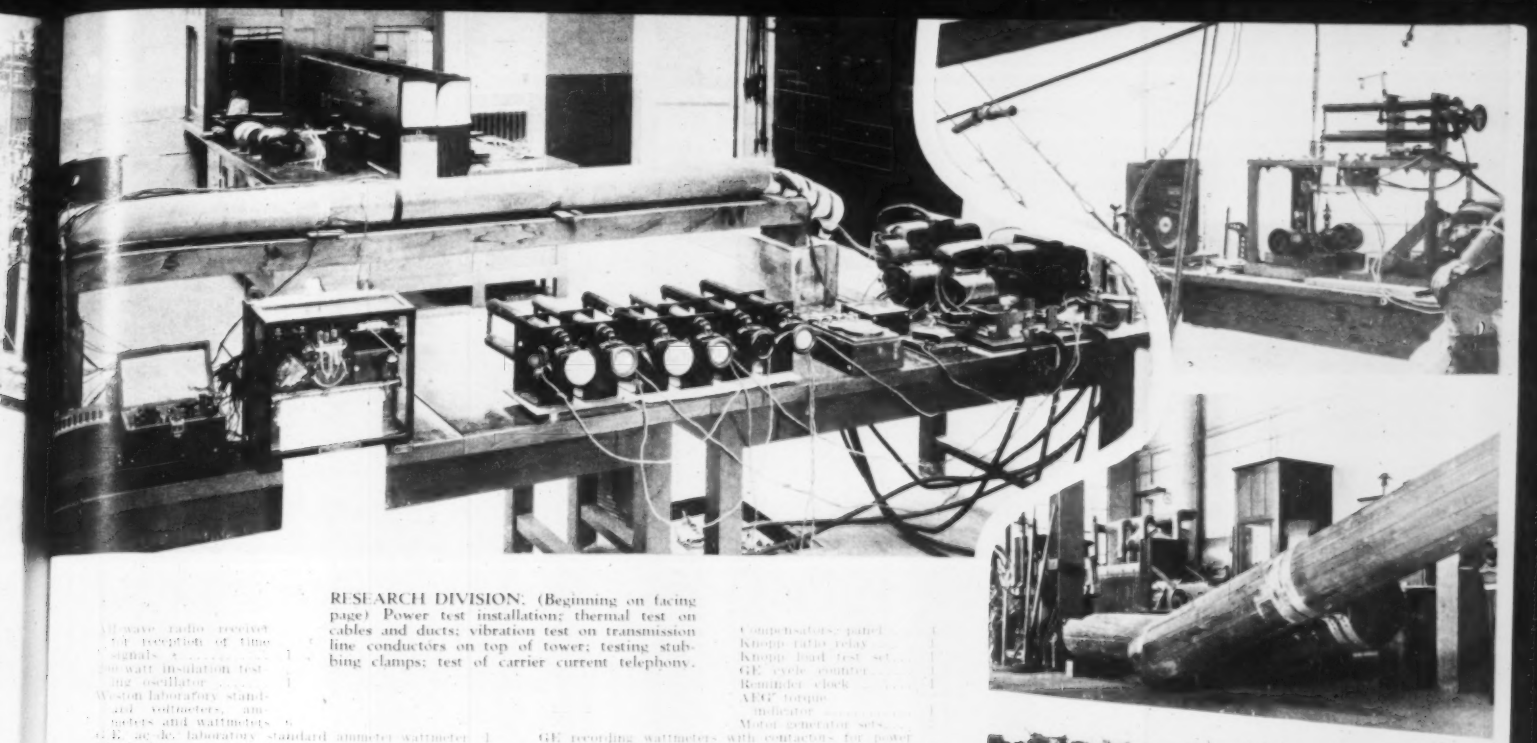
Schneider heads the Electrolysis Division which takes care of the protection of the PG&E Co.'s metallic underground structures to prevent electrolytic and soil corrosion. This work's great value is enhanced by Knopp's system of cathodic protection. Three departments: field surveys; corrosion studies; soil tests.

No space to describe the Bureau's work involving instruments, though thousands of items are worth writing up. Even a bare list runs to thirty-eight typewritten pages! The accompanying photographs taken for *Instruments* convey some idea, as do the following abbreviated lists.

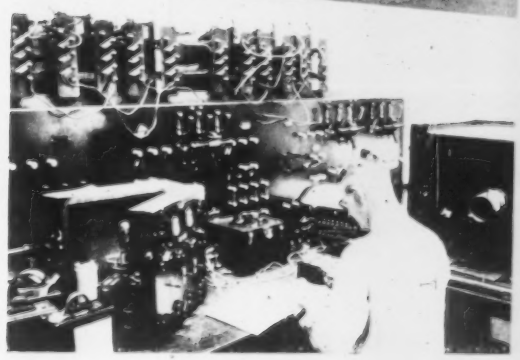
STANDARDS AND MAINTENANCE DIVISION

(A) Standardizing Room

Knopp type millihour pendulum with mercury contacts for operating relays and timing devices in Laboratory	1
Knopp type potential transformer test bench with loading equipment, etc., eight ranges, to 11 kv.	1
Knopp type current transformer test bench with loading equipment, etc. 22 ranges, 2,500 amp. to 5 amp. secondary	1
Knopp type rotating standard test bench, for checking rotating standards, with loading device and timing relay, 14 ranges 0.5-150 amp. and 120-220-240 volts	1
L&N Ross curve tracer equipment complete	1
L&N Type K potentiometer range 1.5 to 1500 volts, with volt box, shunts and 5 spare standard cells	1
Standardizing equipment for illuminometers	1
12" dial Warren Telechron clock with special switching arrangement for frequency checking	1



RESEARCH DIVISION: (Beginning on facing page) Power test installation; thermal test on cables and ducts; vibration test on transmission line conductors on top of tower; testing stub-bing clamps; test of carrier current telephony.



(2) wave radio receiver for reception of time signals
1
100-watt insulation testing oscillator
1
Weston laboratory standard voltmeters, ammeters and wattmeters
6
G.E. ac-dc laboratory standard ammeter wattmeter
1
Westinghouse precision Kelvin balance instr.: volt meter and ammeter
2
Siemens & Halske comb. volt am., megohmer, &c.
3
L&N decade resistance box 0-10000 ohms
1
G.E. rotating standards
3
Knopp type Weston multirange ammeters 2-200 amps
3
Knopp type multirange ammeter 0.05-2 amps
1
Weston Model 370 ammeter 5-10 amps
1
Microammeter with multirange shunt 0.005 to 3.0 amps
1
Weston thermal voltmeter 5-50 volts
1
Weston Model 45 d.c. voltmeter 3-750 volts
1
G.E. Model AP9 d.c. voltmeter 150-600 volts
1
G.E. Model P3 voltmeter 150-300 volts
1
Weston Model 322 millivoltmeter 2-10 mv
1
G.E. DP voltmeter 3-750 volts
1
Weston Model 45 rectifier type a.c. voltmeter 7.5 volts
1
Weston Model 322 heat-flowmeter
1
G.E. Model P3 suspension wattmeter 0.5 watts
1
Knopp type Westinghouse Model 310 Form 2 watt-meter with torsion head 2.5-150 amps
1
Weston Model 603 illuminometer
1
Standard shunts for use with potentiometer 10-1500 amps
8
Misc. shunts 0.75-1500 amps
25
Misc. resistors and multipliers for voltmeters
8
Weston Model 44 tachometer
1
G.E. Model S 8-KTIAL time meter
1
Hasler hand tachometer
1
Esterline electric counter
1
Neon stroboscopic lamp
1
Knopp type portable multirange standard current transformers 0.5-1000 amps
9
Knopp type portable multirange standard potential transformers 110-13,000 volts
3
18" air core inductance for demagnetizing instruments
1
Allen-Bradley carbon rheostats
10
Knopp type carbon rheostats
2
Gen. Radio "Variac" voltage regulator
1
Am. Transformer Co. "Transtat" voltage regulator
1
States Co. Ohm Spun resistor
1
Cenco slide-wire resistors
10
Iron-grid resistor for battery control, 2 volt, 1000 amps
1
Ferranti electrostatic voltmeter
1
Columbia Elec. Co. Tong Test ammeter
1
Beck & Albert phase shifter
1
Portable Vacuum tube voltmeter
1
Low-voltage ring wound calibrating potential transformer
1
Stop watches: Knopp millihour, Meylan 60-sec., Guinard 30-sec.
3

(B) Instrument Repair Room

Bristol, Esterline-Angus, GE, Thompson and Weston record. & ind. wattmeters
12
Bristol, Esterline-Angus, GE, Thompson and Weston record. & ind. voltmeters
17
Esterline-Angus, GE, Thompson, Westinghouse and Weston record. & ind. ammeters
38
GE, Rawson and Weston milliVoltmeters
10
Bristol, Foxboro and Taler recording thermometers
8
Westinghouse iron loss voltmeter
1
Phase rotation indicator
1
Potential adapter, 110-190 volts, open delta to 4-wire 3-phase
1
GE friction & deflection testing device for testing demand registers
1
Hartman & Braun frequency meter, 20 to 80 cycles
1
Knopp multiplier for a-c meter test set
1
Compensator, double, 110/209/440 volts
1
L&N dial decade test sets
2
Am., Ashcroft, Crosby and Foxboro test gages, 30" vac. to 750 lbs./in.²
4
Knopp test panel, for testing bench standards
1
Knopp meter test equipments 0.5/1/1.5/2.5/5/10/15/25/50 amps. 120/230/480 volts for 1 phase, 2- & 3-wire or polyphase watthour meters
2
Insulation test equipment 2300 volts
1
Evershed & Vignoles circuit testing ohmmeter
1
Battery charging panel with voltmeter, ammeters, ampere-hour meter (mercury column), switch-gear, selenium rectifiers, etc.
1
Bausch & Lomb microscope
1
Bausch & Lomb optical lamp with lenses, &c.
1
Compensators, panel
1
Knopp ratio relay
1
Knopp load test set
1
GE cycle counter
1
Remington clock
1
AEG "torque" indicator
1
Motor generator sets
4
GE recording wattmeters with contactors for power factor measurements
3
Knopp multirange potential transformers
1
Knopp multirange current transformers
1
L&N conductivity bridge
1
Insulation testing transformer
1
Carbon & slide wire rheostats
4
Testing set for split core line sets
1
Misc. instrument multipliers
Assortment
Misc. resistors
Assortment
Split cores for various ammeters
Assortment
Compensators & loading transformers
Assortment

(C) Shop

Load-limiting relay testing Wessy heater; 15oo lbs./in.² pressure gage tester; Cenco Hi-Vac pump with auxiliary amp. for pressure and temp. instruments; mercury distilling apps.; low and high heat ovens with automatic controls; 12-ft. mercury manometer; auto-trans-former with percentage taps; large & small Telechron clocks; beside 3o machines.

MATERIAL TESTS DIVISION

(A) Chemical

From the list of 100 classes of items we pick at random a weighing room with concrete vibration-proof table; a creosote distillation apparatus; 101 beakers; 18 graduates; 70 Erlenmeyer and volumetric flasks; 5 drying towers; 255 crucibles; 12 condensers of various types; 6 retorts; 14 ampoules; 6 pyknometers; 25 centrifuges tubes; 2 extraction apparatus; 15 thermometers; 18 API hydrometers; a Becker Chainomatic analytical balance and 2 other balances.

(B) Mechanical

More than 500 items, from which (again at random) we pick force measuring equipment from several explosive torsion balances to a 200,000-lb Riehl Universal with 21 listed auxiliaries; 2 sets Gilmore needles; 19 briquette molds totaling 69 units; various asphalt, concrete, soil, &c. testers; an endurance tester for toggle switches, &c.; a Victor Kviate ultraviolet ray apparatus; 2 polariscopes; 1 Davis Vibrometer comprising vibrometer, vibroscope, motor head, breaker head & illuminator; 6 other types of complete vibration-recording equipments; an anemometer; and a Dos Ansco camera.

(C) Electrical

Perhaps the most representative items are: a special L&N Kelvin bridge 0.001-12.5 ohms; and an apparatus for rubber goods testing & reworking & final high potential tests to 75000 volts.

ENGINEERING INVESTIGATIONS DIVISION

(A) Electrical and Thermal

(1) Supply and Regulating devices.

More than 30 major items such as transformers, regulators, etc.

(2) Special Apparatus and Instruments.

Among the 28 major items are potentiometers, Kelvin and impedance bridges; 4 surge voltage recorders; 1 engine indicator; 1 GE foot candle meter; 1 General Radio string type oscillograph.

(3) Portable Measuring Instruments

7 Voltmeters; 10 ammeters, &c. (six makes, various types).

(4) Relay Testing Equipment

Among 53 major items are: 1 Weston Model 329 polyphase wattmeter; 3 GE Rotating Std. watthour meters; 3 vibration recorders; various GE and Westinghouse Std. & special relays including 4 of the time element current balance type.

(5) Equipment for Gas Tests and Investigations

27 major items include 5 pressure & temp. recorders; 1 steam calorimeter; 1 optical & 2 radiation pyrometers; 3 Neptune hot oil meters; 1 Worthington hot water meter; 1 Pittsburgh Equitable 50-lb. 1000 ft.³/hr. gas meter; 1 American Meter Co. wet test gas meter & standard cubic foot bottle.

(6) Equipment for Thermal Testing

22 Major items include: 2 L&N multipoint recorders; Bristol, Brown, Taylor and Thwing indic. pyrometers; allied equipment.

(7) Apparatus for High-voltage Testing

Includes GE high-voltage (125 kv) test transformer; Stahley compensator; sphere gap voltmeter; equipment for fog, rain and dust tests; etc.

(B) Power Tests

(1) Power Supply Equipment

27 major switchgear items, also an impact pressure gage, &c.

(2) Power Transformers Used in Power Testing

(13 major items, Allis-Chalmers and GE.

(3) Current Transformers Used in Power Testing

9 major items, GE.

(4) Reactors Used in Power Testing

12 iron-core air-gap-to-air-core.

(5) Special Instruments and Apparatus Used in Power Testing

Among instruments are: 1 Westinghouse 3-element (made into 5) oscillograph with remote-control apparatus & elaborate set of auxiliaries & gears; 1 GE Type ME2 synchronous timer.

(6) Photographic Equipment used in Engineering Investigations

Major items include Bell & Howell Model 70D 16 m.m. nop camera, fast lenses, projector & complete set of accessories; Bausch & Lomb Type RM7 photomicrographic equipment complete; a well-equipped dark room.

(7) Misc. Equipment in High Bay for Heavy Testing

Includes: 15-Ton Cyclops crane used for tensile tests; 25-kw a-c-d-c m-g. set; 1 oil filter press; &c.

(C) Radio and Telephone

(1) Apparatus for Radio Tests

Includes: a Kalb interference set; 2 Gen. Radio audibility meters; 1 dictaphone; 1 RCA radio receiver, numerous accessories.

(2) Equipment for Telephone and Communication Tests

A few items are: 1 Gen. Radio a-f oscillator; American and Western Electric amplifiers; 1 DuMont Type 158 cathode-ray oscilloscope; 1 Electrical Specialty Co. 2-kw. dynamotor; &c.

ELECTROLYSIS DIVISION

(A) Field Surveys

2 Ford 1½-ton trucks each fully equipped with a McCollum meter, 3 Bristol recording millivoltmeters, 2 Weston d-c volt ammeters, rheostats, M-Scope pipe finder, radial planimeter, accessories, tools & supplies.

(B) Corrosion Studies

Among instruments: Bristol and Esterline-Angus recorders; 3 pipe locators and signal apparatus; etc.

(C) Soil Tests

Among hundreds of items: 1 Corfield 5-circuit test rack; 5 Sangamo time switches; 1 5-amp. Westinghouse rectifier; Corrosion coupon racks; 50 Bureau Units.

INSPECTION DIVISION

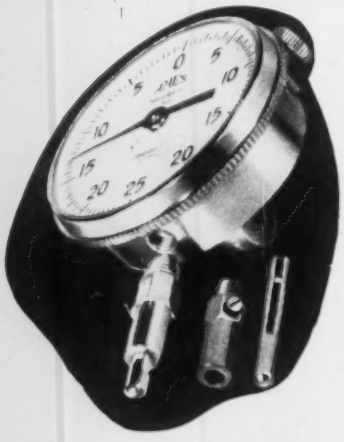
(Major equipment items are several motor vehicles; few instruments are officially assigned to this Division; these instruments are mostly special gages, measuring and inspecting devices, etc. Manufacturers selling to the PG&E Co. usually have insp. & test depts., the facilities of which can be used when necessary by the Bureau's Insp. Div.)

S-M-O-O-T-H VOLTAGE CONTROL for A.C. circuits

The Type "TH" Transtat is the new continuously variable auto-transformer regulator . . . the ideal voltage control for a.c. circuits. It offers high efficiency, good regulation, great flexibility and dependable construction at moderate cost. Standard types are available for controlling voltage to single-phase and polyphase loads rated 10 Kva. and smaller, 50 or 60 cycles, 115, 230 or 460 volts. May we send you bulletin 51-1 which contains complete data?

TRANSTAT
VOLTAGE REGULATORS

AMERICAN TRANSFORMER CO.
178 Emmet St. Newark, N. J.



EASILY CLEANED

The case stem of the Ames Shockless Gauge can be easily unscrewed, the lower half of the spindle withdrawn for cleaning and the assembly replaced without otherwise disturbing the gauge. For details of other exclusive features, send for the Ames Gauge catalogue.

AMES *Shockless* GAUGES
B. C. AMES COMPANY
WALTHAM, MASS. 6310

NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

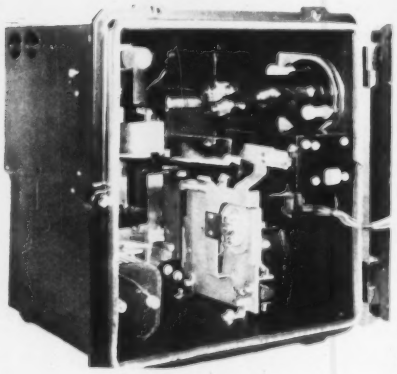
Or write to Information Section, Instruments Publishing Company.

Polarizing Units for Microscopes

Any standard microscope can be converted into a polarizing instrument by attaching two new "Polaroid"-equipped units: (1) Analyzer, fitting over eyepiece, is graduated in 5° divisions over 180° and has an 11-mm. aperture. (2) Polarizer available in two styles: (a) duralumin-mounted 23-mm. aperture disk fitting into sub-stage condenser, leaving top of stage free for manipulation; (b) duralumin-plate style with 11-mm. aperture disk in center, to be placed on stage with specimen slide on top of it. "Polaroid" medium has a structure sufficiently minute for this application, is not affected by heat from most intense illuminants used in microscopy, has a polarizing effectiveness of 99.5% for visible light. *The Polarizing Instrument Co., 8 W. 30th St., New York City.*

Throttling Controller For Electric Furnaces

Economical means for obtaining throttling control of electric furnaces and ovens are said to be afforded by new model "Celectray" indicating controller; with it, no other equipment is required than ordinarily used for on-and-off control. This is an indicating potentiometric controller with photoelectric detection of



the position of a light beam reflected from a mirror galvanometer toward a reciprocating "controlling edge." It makes the heat supply vary inversely as the temperature; is said to have no measurable dead zone and to hold a steady temperature "instead of the oscillating temperature of on-and-off control." Life of the furnace switch or magnetic contactor is maintained by selecting the frequency of cycles according to the power requirements. Throttling zone can be readily adjusted within wide limits; "load error" or "droop" can be kept within a few degrees without introducing appreciable hunting. In many cases a precision instrument is required to detect any variation in temperature, it is said. Adjustment for "load error" is provided. A safety feature is that when the lamp is burned out power is shut off. Instrument resists vibration, but shock-proof mountings are available. Circular scale and slide wire are 15" long and temperatures can be read to 0.4% of range. Scale appears through a glass window and temperatures are indicated by a brilliant white, red or green line of light on ground glass. This indication is visible "at a great distance." *C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y.*

Ultra-sensitive D-c. Multimeter

New "Ultra-Sensitive DC Meter" was developed for accurate measurements of ionic and electronic currents, employing a new electronic circuit giving sensitivity comparable to that of "average reflecting galvanometer." Accuracy ± 2%. Instrument cannot be easily damaged or burned out by overload currents. Twelve ranges for current measurements to 10,000 microamps, lowest full-scale reading 0.02 microamps. Eight voltage ranges 0.1-500 volts, with 5 megohm resistance. For resistance measurements, two ranges 0.1-100 and 20-1000 megohms, with less than 0.5 volts across resistance; with 90 volts, up to 200,000 megohms. Instrument is self-contained, battery-operated; requires no external resistance or shunts; essentially consists of a multiplicity of input circuits, a feed-back type amplifier and an indicator circuit. Sensitivity stability is "automatic"; no maintenance of critical adjustments. Instrument is 13" high, 9" wide, about 9" deep, weighs 20 lbs. with batteries. *Engineering Products Div., RCA Mfg. Co., Camden, N. J.*

Frequency Modulator

New "Model 529" frequency modulator can be used with any signal generator or oscillator so that, in combination with a cathode-ray oscilloscope, visual alignment of receivers is possible. *Supreme Instruments Corp., Greenwood, Miss.*

"Meg" Insulation Tester

"MEGGER"

TRADE MARK REGISTERED U.S. PAT. OFF.

INSTRUMENTS

Today the trade-name "Megger" embraces a wide variety of portable direct-reading instruments for measuring—

1—insulation resistance up to 10,000 megohms

2—conductor resistance down to .000001 ohm

3—ground resistance in ohms

4—capacitance in microfarads, and

5—water purity in units of conductivity

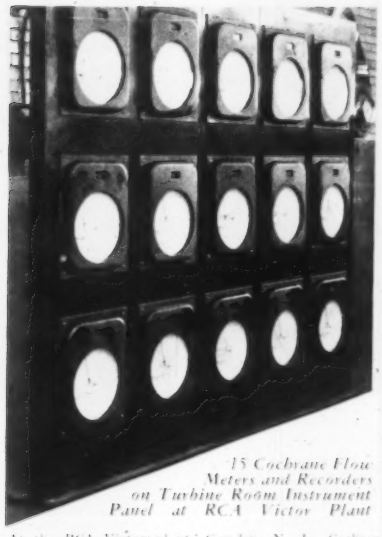
Appropriate literature will be sent gladly upon request.

JAMES G. BIDDLE CO.

ELECTRICAL INSTRUMENTS

1211-13 ARCH STREET PHILADELPHIA, PA.

Cochrane at RCA



15 Cochrane Flow Meters and Recorders on Turbine Room Instrument Panel at RCA Victor Plant

At the RCA Victor plant, Camden, N. J., Cochrane Meters and Recorders provide engineering and operating departments with a constant check-up on boiler and turbine performance . . . adjustments can be made quickly for maintaining high efficiencies.

To protect large expenditures for modern generating equipment, accurate control and measurement of fluid flow is essential. Cochrane Flow Meters are preferred for their extreme accuracy.

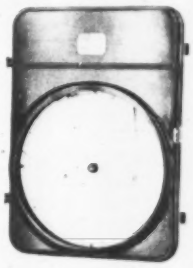
Write for Publications 2081 and 2096

COCHRANE CORPORATION

3120 N. 17th St. Philadelphia, Pa.

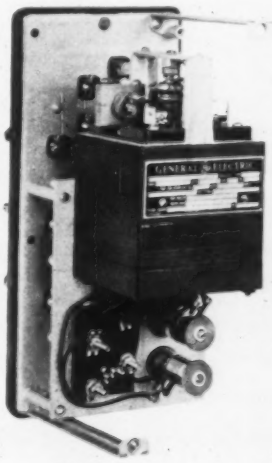
Electric-contact Type Recorder-controller

Another addition to "Pyromaster" line (see *Instruments*, April '37, page 97; July '37, page 172; Nov. '37, page 277) is announced: an electric-contact type recorder – controller said to provide close control free from chattering at contact points, by use of "Unitact" relays, which require making and breaking of only one contact to effect control. Instruments may also be built to operate with standard relays that require contacts for both making and breaking the controlled circuit. The same modes of control are obtained with the Pyromaster "Unitact" Controller as with standard relays: high, low, high-low, high-off-low, and high-normal-low. *The Bristol Co., Waterbury, Conn.*



Directional Relay With Voltage Restraint

New Type CBP polyphase power directional relay has two cup-type torque-producing elements on one shaft, one a



polyphase power-directional element, the other a voltage-restraint element. Relay normally stays in the open position; when a fault occurs, voltage restraint collapses, allowing directional element full control. It can be used with instantaneous as well as delay overcurrent relays, as it cannot close its tripping contacts on load current; only the control voltage is on the contacts. *General Electric Co., Schenectady, N. Y.*

Heat-sensitive Inks

In March 1937 *Instruments*, page 65, there was announced a line of paints changing color at various temperatures; colors and alteration-points were tabulated. Maker now announces that some of these thermoscopic chemicals, in suitable vehicles, are available as printing inks. ("Thermoscopinks" we might call them.) *The Efkalin Co., 272 Greenwich St., New York City.*

BAILEY METER CONTROL SYSTEM

The Mark of Effective Control

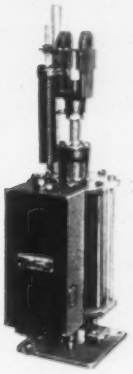
Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

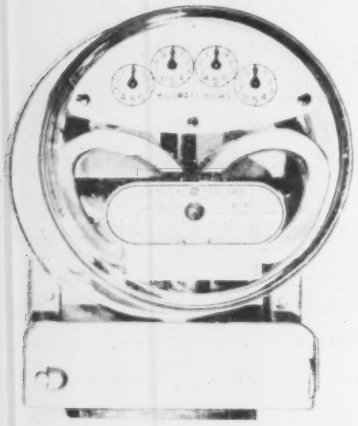
G-3

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

Watthour Meter

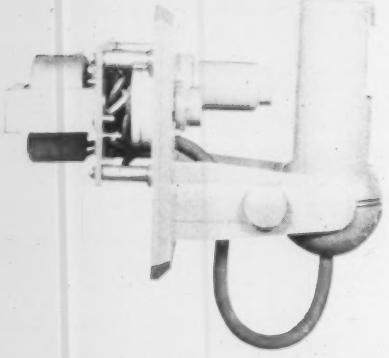
New Type I-30 single-phase wide-limit watthour meter's performance is equivalent of four sizes of previous types: 5-, 10-, 15-, and 25-amp. ratings. With a nameplate rating of 15 amp. it has a



practically flat accuracy characteristic from 0.5 to 60 amps. A new driving element with compensating shunt for high- and low-current values and a new light-load and lag adjustment (compensated for the effect of temperature variations when loads of less than unity power factor are being registered) are among features. *General Electric Co., Schenectady, N. Y.*

Lighting Control

Designed to keep the light in a room or building at the proper level for satisfactory work, new CR 7505-D61 control unit embodies a photofube set up so that natural light coming through the windows falls on it and, when below predetermined level, operates a relay which in turn operates the lights. Two adjust-



ment knobs are located on the control panel: one determines the light level at which unit will turn on artificial light; the other sets the level at which artificial light will be turned off. Two models available: flush mounted for wall installations in new buildings; surface-mounted for use where undesirable to cut into room walls. Connections to lighting circuit are made at the regular wall switch. *General Electric Co., Schenectady, N. Y.*

MOISTURE TELLER

Rapid and accurate moisture test in percentage by drying. Ideal for plant moisture control or laboratory moisture determinations.

Time required to dry most materials is one minute.

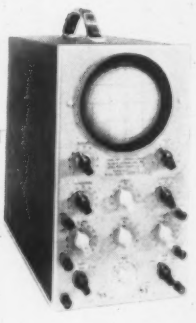
Suitable for granular—fibrous—crystalline materials in industries such as:

Sand—Textile—Tobacco
Ceramic—Rubber—Food
Wood—Mining—Leather

Write for Literature

Harry W. Dietert Co.
9330 Roselawn Avenue
Detroit, Michigan

Du MONT
Type 168—5 Inch All-Purpose
OSCILLOGRAPH



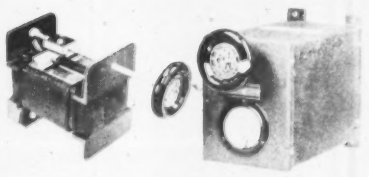
This modern Cathode Ray Oscillograph incorporates many advanced features. It employs a Du Mont type 54-XH, 5 inch Cathode Ray Tube which provides a hair line trace, uniform focus over the entire screen, long life and high intensity. The features of two stages of amplification on the vertical, separate power supplies for the cathode ray tube and sweep circuit insuring no interaction of controls, a high gain sweep expanding amplifier which allows observation of waves of much higher frequency than the fundamental frequency of the sweep, are only a few of the features which make the type 168 an outstanding instrument.

For complete details write

Allen B. Du Mont Laboratories
INC.
Upper Montclair, New Jersey

Manual Voltage Regulator

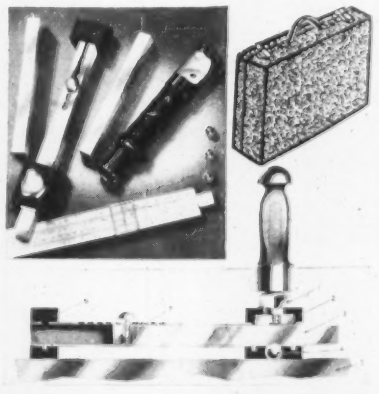
For manual compensation of fluctuating a-c. lines, new "Type RH Transtat" provides smooth uninterrupted control in steps of approximately 1.0 volt each. Designs have been developed for correcti



voltage throughout a range of ± 9 volts from normal (10-volt total range on lines of 230-volt nominal rating or lower. Line currents up to 35 amps. can be handled successfully; types can be furnished for either single-phase or polyphase operation. This is an adjustable auto-transformer, said to have an exceptionally high electrical efficiency, low exciting current and practically no effect upon either power factor or wave form. *American Transformer Co., 178 Emmet St., Newark, N. J.*

Portable Brinell

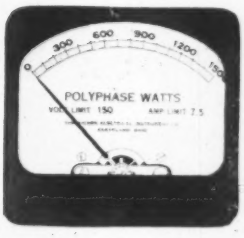
New "Telebrineller," portable Brinell instrument, weighs 6½ lbs. with case, permits metal hardness tests in the field, can be applied to parts and equipment the size of which sometimes made testing virtually impossible. Was developed to test welded rail ends on the right-of-way. Instrument proper consists of a metal tube supported in a soft rubber head (2) and a rubber spacing block (6), the tube holding *a bar of known hardness* (3). An anvil (1) in top of rubber head rests directly on this bar. Below bar, impression ball (4) comes in direct contact with the metal to be tested. Spacing bar (7) holds the bar in a clear area for each test. *Procedure:* Anvil is struck a sharp hammer blow. Impact is transmitted through anvil to known-hardness bar, then to ball and on to specimen. Force of blow is said not to be a factor, diameters of impressions in bar and in specimen being, in any case, relative to their individual Brinell hardness numbers. Impressions diameters are then measured in 0.1 mm. by microscope of outfit. Hardness number of unknown is obtained by slide-rule supplied with outfit. *Telezeld, Inc., Railway Exchange Bldg., Chicago, Ill.*



HIGHEST

HICKOK

ACCURACY



WATTMETERS
FREQUENCY METERS
POWER FACTOR METERS
VOLTMETERS
AMMETERS, ETC.

4" Rectangular Cases, Flush or Surface Mounting. With or without illuminated dials. Neat, attractive, easy to mount.

COMPLETE INFORMATION UPON REQUEST

Manufacturers of all sizes and types of Electrical Indicating Instruments.

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ELECTRICAL INSTRUMENT COMPANY

10514 DUPONT AVE., CLEVELAND, OHIO

An All Purpose

AIR VELOCITY METER

"Alnor" Velometer

Instantaneous Direct Reading

No Timing
No Calculations
Write for Literature

ILLINOIS TESTING LABORATORIES, Inc.
142 W. Austin Ave. Chicago, Illinois

Surface Temperatures

Flat Stationary or Moving Curved Surfaces

The "Alnor" Combination Pyrocon

Ideal for rolls, molds, plates, platens and plastic material temperatures.

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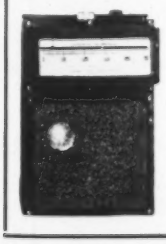
Illinois Testing Laboratories, Inc.
142 W. Austin Ave. Chicago, Illinois

ALNOR Electronic Type



PYROMETER CONTROLLER

For all industrial applications

Ranges 0-600 to 0-3000

Write for bulletin

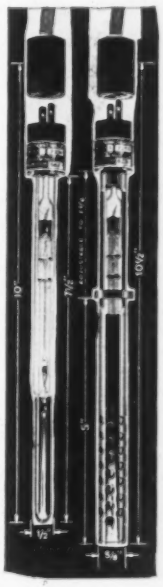
ILLINOIS TESTING LABORATORIES, INC.
142 W. Austin, Chicago, Ill.

Oscillograph

Designed for complete visual alignment and service when used with any good frequency modulator or frequency-modulated oscillator, new RE05 Oscillograph has its 3" cathode-ray tube mounted at angle, putting the (removable) screen

normal to line of vision; has focusing, intensity and positioning controls, automatic synchronization, two sweep circuits with flexible wide range: linear variable from 3 to 150,000 cycles, and 60-cycle sinusoidal for simplification of visual alignment. Locking sweep circuit eliminates image wandering. Amplifiers have flat response curve up into r-f. High input impedance, 1 megohm horizontal and vertical. Dimensions 11" × 9" × 8". *The Hickok Electrical Instrument Co., Cleveland, Ohio.*

Thermoregulators



New models of the "Red-Top" thermoregulators (see *Instruments*, Oct. 1932, page 252) are announced. They may be had for heating or refrigeration control, in plain or armored forms, making four new models. Operating principle remains that of modified Beckmann thermometer. Ranges from 30°F. to 500°F. Accuracy, 0.1°F. Primarily designed for constant-temperature baths; adaptable to humidity control by use of wet wick. Maker has complete line of sensitive relays. *H-B Instrument Co., 2358 N. Broad St., Philadelphia, Pa.*

Portable Timer

New "No. 75M" portable timer for accessory requirements, makes available for general utility use the features of the "No. 75" which, heretofore, were adapted only to standard-equipment installation: simple operation, setting by means of a knobbed dial, positive quick-make and quick-break switch action, etc. An improved switch mechanism utilizes cone-center principle and provides "immediate closed circuit settings for even the shortest interval." Available in 15-, 30- and 60-minute maximum timing ranges. Switch capacity 15 amps, 125 volts, a-c. and d-c. *Walser Automatic Timer Co., Graybar Bldg., New York City.*

New . . .

GUTHRIE-LEITZ

Automatic POLISHING MACHINE

New and Outstanding Features:

1. Three or more specimens can be polished simultaneously.
2. A new specimen holder automatically rotates the object, guaranteeing evenly polished surfaces plane to the edge.
3. Specimens in bakelite mounts can be used.
4. An electro-magnet of variable strength below the polishing disc exerts a uniform pull to the specimen against the polishing disc.
5. Continuous speed regulator permits changing from 350 to 1000 RPM while machine is in action, retaining full strength of motor.
6. All parts are easily removable for cleaning. Changing the polishing disc requires only a few seconds.

E. LEITZ, Inc.

730 Fifth Avenue, New York, N. Y.

Washington Chicago Detroit
Western Agents: Spindler & Sauppe, Inc., Los Angeles—San Francisco

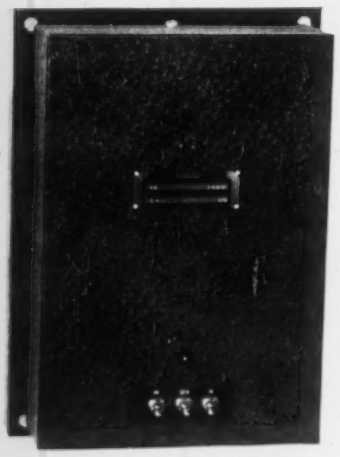
Set Tester

New wide-coverage No. 1800S has a built in multi-selector with a complete set of leads and adapters for socket analysis. Its ranges are said to cover every

present need and many future requirements: D-c. volts 0/10/50/250 at infinite ohms per volt. A-c. and d-c. volts in five ranges at 1000 ohms per volt. D-c. microamps 0-500. D-c. milliamps in three ranges. Five ohm ranges to 10 megs. and readable to 0.05 ohms. Five ranges of microfarads. Output same as a-c. volts. Also decibels and henries. Batteries operate all except the highest range of ohms and capacity meter which operate from built in power supply. *The Hickok Electrical Instrument Co., Cleveland, Ohio.*

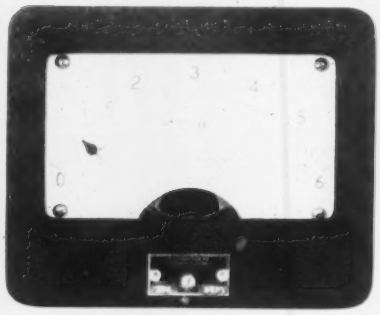
Vibrating Type A-c. Voltage Regulator

Designed to maintain constant voltage on generator bus in buildings, industrial plants and other power installations where large load fluctuations occur, a



new line of vibrating type voltage regulators is added to maker's regular line of carbon pile regulators. Frequency of contact vibration is adjustable over a range wide enough to meet extreme conditions. Main contacts are of platinum-iridium alloy; relay contacts of silver or tungsten; pilot contacts of silver. Principle of automatic regulation assures quick response to load changes and absence of dash pots minimizes maintenance. Construction is dead front. Energy consumption approx. 100 watts. *Ideal Commutator Dressing Co., 1320 Park Ave., Sycamore, Ill.*

New Type
Thermo-electric Indicating Pyrometer



Total Scale Ranges as Low as 0-600° F.
Scale Length, Full Six Inches
Cold-junction Compensation
Copper Error Compensation
Zero Adjustment

Install "Engineered" Pyrometers and Thermocouples to solve that difficult low temperature problem.

Lewis "Engineered Instrumentation" is not merely manufactured, it is engineered.

Write for Bulletin 11-37-12

THE LEWIS ENGINEERING CO.
NAUGATUCK, CONN.

Several Sales Territories Now Open.

WHY TAKE A CHANCE

A few cents saved may mean thousands of dollars lost.

Quality in a thermometer is unseen and your faith in the manufacturer is your guarantee of the quality.

If the product you are testing is worth testing at all, it is worth a good thermometer, which will not change with age or use.

Specify on your next order:

PALMER
"Red—Reading—Mercury"
THERMOMETERS

with the wide RED column, made of selected glass and guaranteed absolutely accurate.

A trial will convince you!
(No. 500-B catalog FREE)

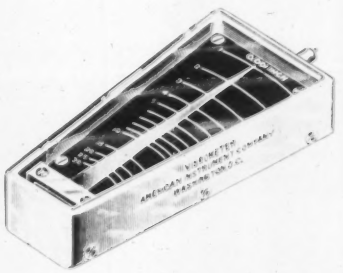
THE PALMER COMPANY
MANUFACTURERS
I.S.T.M., Laboratory and Industrial Thermometers
2811 Norwood Ave., Cincinnati, Norwood, Ohio
Canadian Plant: King & George Sts., Toronto

Recorder-controllers

Round-chart recording thermometers with or without Micro Switches for automatic-control uses, are announced in wide and flush types, in ranges 50-350, 100-650 and 100-1000° F., with interchangeable mercury-in-steel elements, each instrument using a stylus for recording on 10" sensitized-paper charts. Combination of low friction and unusually high energy of thermal element for a given temperature change, minimizes frictional errors in measurement. This, together with extremely low energy absorption of Micro Switch, permits attainment of narrow differential in automatic-control application. *The Partlow Corp., New Hartford, N. Y.*

Vibrometer

New Vibrometer for measuring the amplitude of vibration of structural or machine members, has a range from 0.001" to 0.030" amplitude. In use, it is held in the hand and the needle point held against the vibrating part whose amplitude is to be measured. Motion of spindle is transmitted directly to Vibrometer pointer which appears as bright

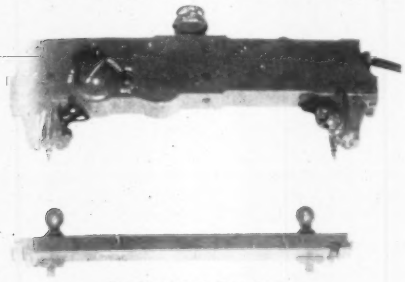


yellow against a black background. This pointer appears double to observer's eyes; apparent intersection of the two images, read on scale on background, gives amplitude of vibration directly in thousandths of an inch. Instrument is made heavy (2 lb.) to avoid inertia effects during use. Construction prevents damage to instrument when it is applied to a member vibrating with amplitude greater than 0.030". *American Instrument Co., 8052 Georgia Ave., Silver Spring, Maryland.*

Rapid Photoelectric Counting & Sorting

Many industrial applications of photoelectric devices cannot be solved with electrically-driven mechanical counters having relatively low maximum operating speeds. To overcome this difficulty, there has been developed a "ratio differential control" which multiplies the speed of a mechanical counter by a factor of 2-4-8-16, etc. It furnishes one impulse to the final counter circuit for a definite number of interruptions of the light beam. The ratio is said to be "absolutely accurate and unchanging." Moreover, the counter is energized and deenergized just 50% of the time regardless of the percentage of time the light beam is interrupted. The standard "scale-of-two" control supplied with a special Veeder-Root reset counter will safely count up to 5000 per minute, it is said. *United Cinephone Corp., 33rd St. and Queens Blvd., Long Island City, N. Y.*

Microparallactic STRAIN GAGE



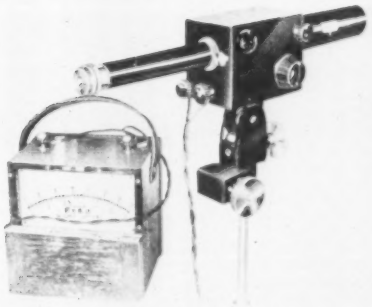
Developed and licensed by
Goodyear Zeppelin Corporation

AN OPTICAL instrument especially adapted for strain measurements in construction work involving the use of thin sheets and flexible members as in aircraft. A single eyepiece is used on two illuminated hair lines at the gage points. Differential movement is measured on a graduated scale within the eyepiece, or by a filar micrometer. Magnifications of 10 or 100 may be had. No force is required to apply the instrument which eliminates possible distortion of the member. Readings are direct and accurate. In special cases glass or metal targets prepared in advance may be affixed to the metal. If you have a problem in strain measurement, or in the calibration of strain gages, write us.

O. S. PETERS

Testing Equipment—Special Instruments.

1236 Mount Olivet Road, N. E., Washington, D. C.



Micro Optical Pyrometer

Combining a 20-power 37-mm aperture telescope with a filament-brightness-matching arrangement, new Micro Optical Pyrometer permits measuring temperatures of minute incandescent objects. The image of ordinary lamp filament, for example, can completely cover the tip of the pyrometer filament image. New instrument makes it possible to measure true temperatures of low-emissivity materials by sighting the bottom of (1) a small refractory tube inserted in molten material or (2) a small hole in solid material. *Pyrometer Instrument Co., 10-5 Lafayette St., New York City.*

Pneumatic Submaster Room Thermostat

Regulates temperatures in a room with relationship to conditions at another point: by installing this Submaster Thermostat under the regulation of a master

appearance, reduced to half its former size. All moving parts operate in a sealed chamber. Designed for use with all types of heating and cooling controller placed at an outside location, inside temperature will be raised, for example, from 72 to 80° F. as outdoor temperature rises from 70 to 100° F. Simplified in design, improved in equipment where graduated control by compressed air is desired: an air line from the master controller operates a bellows on the back of the Submaster thermostat, mechanically changing its setting. Submaster feature can be disconnected so that instrument will operate as a conventional room thermostat. *Natl. Regulator Div., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Oscilloscope

New "Model 521" cathode-ray oscilloscope utilizing a 2" tube is said to be of special interest to hams and experimenters. Has power supply, intensity and focus controls, input jacks to vertical and horizontal plates and an internal sinusoidal sweep supply with gain control. External linear sweep may be used. Can be used for visual alignment with addition of external vertical amplifier. *Supreme Instruments Corp., Greenwood, Miss.*

Double Old Sensitivities

Thermal meters for use on any frequency measuring quantities of ½ the values on previous meters.

Bulletins 502 and 502-A

Dynamometers, wattmeters, milliammeters and voltmeters. Also ultra-sensitive meters both for A.C. & D.C., fluxmeters, electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, etc.

Photo Electric Cells—"Electrocell"

Acknowledged leaders in development of high sensitivity meters

RAWSON Electrical Instrument Co.

CAMBRIDGE, MASSACHUSETTS
15 E. 26th St., New York
1313 W. Randolph St., Chicago
Special Apparatus Built to Order

To Gauge the Progress of Today's Accelerated Pace . . .

In Industry, Science and Transportation . . . The need for Accurate Timers assumes Greater Importance . . .

GUINAND; GALLET GALCO and SECURITY

Timers set the Standard for Enduring Dependability

Write for Catalog 7F

JULES RACINE & CO.

20 WEST 47TH ST., NEW YORK

IMPROVED "SPOTLIGHTS"

Rubicon MULTIPLE REFLECTION galvanometers have recently been much improved through redesign of optical system. The definition of the line-image is now so sharp that readings can be estimated to .1 of a millimeter division.

These sturdy self-contained galvanometers are available with sensitivities as high as 5×10^{-9} ampere and 1×10^{-6} volt per millimeter division.

ASK FOR BULLETIN 520

RUBICON COMPANY

Electrical Instrument Makers

29 North 6th St. Philadelphia, Pa.

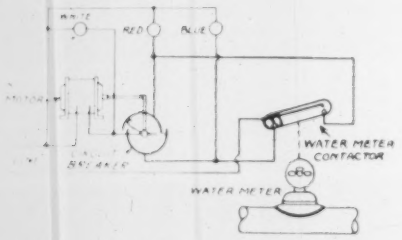
Galvanometers, Electrometers, Potentiometers, Colorimeters, Wheatstone & Kelvin Bridges, Resistance Standards, Resistance Boxes, Coil Testers, Clip-on Ammeters, etc.

Polarizing Device for Microscopes

Said to enable an observer "to instantly detect defects" (strains, etc.) and irregularities in transparent materials such as glass, rubber, plastics, etc., the Marko Polarizer and Analyzer slips into place on any microscope for instant use. In the case of opaque materials (ores, metals, alloys, ceramics) thin sections are made. New device facilitates identification and grading of crystals, dusts, food products, plant fibers, drugs, textiles, lacquers, living tissue, leather, lubricating greases, etc.—*The Laboratory Equipment Company, 158 Lafayette St., New York City.*

Dry Chemical Metering Feeder

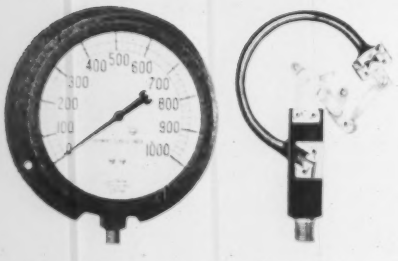
A new dry chemical feeder is announced in capacities to 100 lbs./hr. for activated carbon, etc., and to 150 lbs./hr. for sodium aluminate, etc. (other materials in between). Feature of interest to



Instrument readers is that its intermittent discharge volumetric feeding device can be commanded by impulses from the integrator of a fluid rate meter or from the register of a positive fluid meter, in order to effect automatic proportioning control.—*The Permutit Co., 330 W. 42nd St., New York City.*

Refinery Gage

For pressures below 100 lbs. this new pressure gage especially designed for refinery service embodies a drawn steel Bourdon tube; for pressures above 100 lbs. it incorporates a lathe-turned tube (illustrated), rough-bored, rebored and reamed to 0.0005". By employing lathe threads and a special socket and cone, it is said, a joint has been developed that will hold tight up to melting point of steel. Movement is of stainless steel and Monel metal. New method of zero ad-



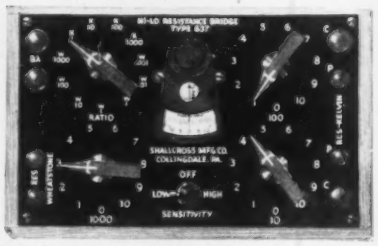
justment (known as "Recalibrator") was developed to nullify tube distortion error; correction is made by using a screw driver. Once made, readings will then be correct at all points, it is said. New gages are moisture-, vapor- and dust-proof. Cases are rust-proof.—*Jas. P. Marsh Corp., 2075 Southport Ave., Chicago, Ill.*

The New

TWO-IN-ONE SHALLCROSS

HI-LO RESISTANCE BRIDGE

A convenient compact little instrument, completely self contained for measuring any resistance from .00001 ohm to 11.1 megohms.



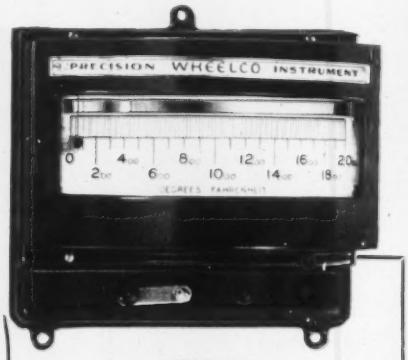
Specially practicable for measuring the resistance of relay contacts, coils, armature windings, etc.

This one unit includes both a standard Kelvin Bridge and a standard Wheatstone Bridge.

Send for Bulletin 637-HD.

SHALLCROSS MFG. CO.

COLLINGDALE, PA.



MODEL 101

Indicating Pyrometer

High Resistance Millivoltmeter Type

A super-sensitive instrument, built to the highest standards. Automatically compensated for cold junction. Has dustproof aluminum case—finished with black baked enamel—wide open face and 6" mirrored scale. Choice of scale range and calibrations.

Data	PRICE
Furnished on Request	$60

WHEELCO INSTRUMENTS CO.

1933 SO. HALSTED STREET, CHICAGO, ILL.

Polariscope

Designed for rapid inspection, as production lines, and suitable for laboratory work, strain detection, engraved textile examiners, etc., new "Colorscope" combines a light source and polarizing system containing a "Marks Polarizing Plate" said to be "the only polarizing medium in the world which is color-neutral," anr a housing with two Marks polarizing-medium eyepieces used as analyzers. Each eyepiece is individually rotatable. Instrument may be used as a gloss-meter, etc., by substituting a photocell and galvanometer (such as a photocell and galvanometer) for the eye.—*Polarized Products Corp., Whitestone, L. I., N. Y.*

Time Recorder

New "Uni-Speed" is one-hand operated, prints employees' time on front of cards, automatically prints tardy or irregular registrations in red, is said to operate

accurately under conditions of dust, dirt, and vibration.—*Stromberg Electric Co., 233 West Erie Street, Chicago, Ill.*

Automotive Engine Analyzer

New Potter Engine Analyzer is a self-contained unit in the form for a cabinet mounted on casters for easy rolling to the automative vehicle. Individual instruments are: (1) gas analyzer; (2) coil tester; (3) electron condenser tester; (4) "Avo Test Set" described as "eight instruments in one" for performing all other electrical measurements; (5) pressure and vacuum gage. Supplied with analyzer is a system of large envelopes of data for all car models from 1933 to date. Analyzer is 16" long, 34" high and 15" deep, has special drawer for data envelopes, space for storing leads, hose and fittings, etc.—*The Potter Co., 1950 Sheridan Road, North Chicago, Ill.*

Do you own this copy of Instruments?

See Page A9

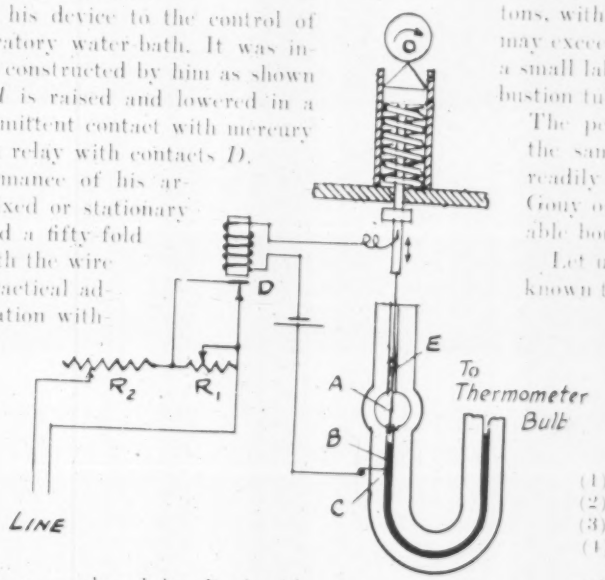
Note on the Throttling of Electric Heat

By C. OWEN FAIRCHILD
Director of Research, C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

WHEN temperature control within a few degrees is required, the choice between electric and fuel-fired industrial furnaces (or ovens) is sometimes made in favor of the latter because—supposedly—no economical means are available for throttling electric heat, as gas or oil fuel is throttled with well-known types of controllers. It is the purpose of this article to point out that economical means *are* available for throttling electric heat, without the use of rheostats, induction voltage regulators, electronic equipment, etc.

It is strange indeed that forty years elapsed between the invention of a method of throttling electric heat and its industrial application. In 1897 Gouy[1] invented an electric controller in which the time of contact of a reciprocating member with the measuring element varies inversely as the temperature. The effect of this inverse relation is strictly the throttling mode of automatic control[2], also termed "corresponding"[3], that is, the heat supply varies inversely as the temperature. Properly applied, the Gouy device affords all the advantages of ordinary throttling control and has only one possible secondary disadvantage, namely, shorter life of a magnetic contactor. We shall show presently that this can be made, in truth, a secondary consideration.

Gouy originally applied his device to the control of the temperature of a laboratory water-bath. It was invented again by Sligh[4] and constructed by him as shown in Fig. 1. Platinum wire *A* is raised and lowered in a constant cycle making intermittent contact with mercury meniscus *B* and operating a relay with contacts *D*. Sligh compared the performance of his arrangement with that of a fixed or stationary control contact and observed a fifty-fold improvement in control. With the wire *A* fixed he found that a "practical adjustment" resulted in regulation within 0.005 C. of a bath for a precision Wheatstone bridge, while with an oscillating contact "the variation in bath temperature as indicated by a calorimetric platinum resistance thermometer was less than 0.0001 C."



The Gouy method has been employed by Roebuck and many other experimenters for improving their laboratory thermoregulators, and has been applied to industrial automatic controllers, such as the Tirrill vibrating voltage regulator, the Parsons "puff governor" and some arrangements of "astatic electronic voltage regulators" as they are described by Gulliksen and Vedder[6]. It should be pointed out that many of those arrangements and mechanical ones like those of Luis de Florez[7] resemble the Gouy method mainly in being cyclical but are not exactly like it, and hence do not have its advantages.

Now we do not propose for the present to control a large heat-treating furnace or an enameling oven within 0.0001 C. as Sligh was able to do with a laboratory thermostat, nor to apply a Gouy oscillator to a 150-amp. magnetic contactor with a frequency even near that of the Tirrill regulator. The problem of automatic temperature control is unlike those of voltage regulation or steam-turbine governing, as unlike as the terms used to describe them. The dissimilarity is particularly significant in three respects:

(1) Temperature waves travel slowly through a furnace;	(1) Voltage waves travel rapidly;
(2) The heat capacity is generally large;	(2) Electrical capacities are generally small;
(3) Attenuation of temperature wave through a solid is high; greatly damps tendency to hunt.	(3) Voltage attenuation (*e.g.* in a generator) is almost negligible.

The natural period of temperature oscillation or "hunting" of a furnace weighing a few tons, with its charge, under throttling control may exceed twenty minutes, and the period of a small laboratory furnace for heating a combustion tube may be as much as five minutes. The period of "on-and-off" control is of the same order of magnitude. Thus it is readily apparent that the period of the Gouy oscillator can be kept within reasonable bounds, say one to five minutes.

Let us recite briefly the principal means known to be available for throttling control of resistor furnaces. All of these but the last named require a reversible motor drive, for which there are a number of throttling controllers on the market such as the "Celectray," "Electr-o-Line" and "Micromax":

(1) Rheostat;
(2) Induction voltage regulator;
(3) Tapped transformer;
(4) Slide-wire transformer (for small furnaces);
(5) Saturable reacter or transformer;
(6) Grid-controlled gaseous-discharge tube with grid connected to a motor-driven potentiometer or capacitor;
(7) Same tube with grid conductively coupled with the measuring voltage circuit which may be amplified from a thermocouple or photoelectric circuit.

All but the last have an unavoidable dead-zone and more or less motor drift. The last may be theoretically free from a dead-zone, because it has no mechanical follow-up, but it has not been available for accurate temperature control. It has in particular the troublesome limitation that the measuring or thermoelectric circuit is connected to the power circuit.

An attribute of a controller using the Gouy principle to the fullest advantage is that *there is no measurable dead-zone*. So far as we know, the performance of the Gouy-principle controller has not been excelled. From the standpoint of accuracy, then, it may be preferred to

Continued on page 312

[1] Various patents issued to The Texas Co.

[1] Gouy, Sur une Étuve à Température Constante, *Journal de Physique*, Vol. 6, 1897, pages 479-483.

[2] M. F. Behar, Handbook of Industrial Temperature and Humidity Measurement and Control, Instruments Publishing Co., Pittsburgh, 1932, Chapter X (pages 235-260).

M. F. Behar, Automatic Temperature Control, *Instruments*, Vol. 3, July 1930, pages 425-462, "Modes of Control," pages 431-440.

[3] Ed. S. Smith, Jr. Automatic Regulators, Their Theory and Application, *Transactions ASME*, Vol. 58, 1936, pages 292-305.

[4] T. S. Sligh, Jr. Some Characteristics of the Gouy Thermoregulator, *Journal Am. Chemical Society*, Vol. 42, Jan. 1920, pages 60-68.

[5] J. R. Roebuck, Mechanical Thermostats, *Journal Optical Society of America and Review of Scientific Instruments*, Vol. 10, 1925, pages 679-690.

J. R. Roebuck, Sensitive Flexible Thermostats, *Review of Scientific Instruments*, Vol. 3, 1932, pages 93-100.

[6] E. H. Gulliksen & E. H. Vedder, Industrial Electronics, John Wiley & Sons, New York, 1935.

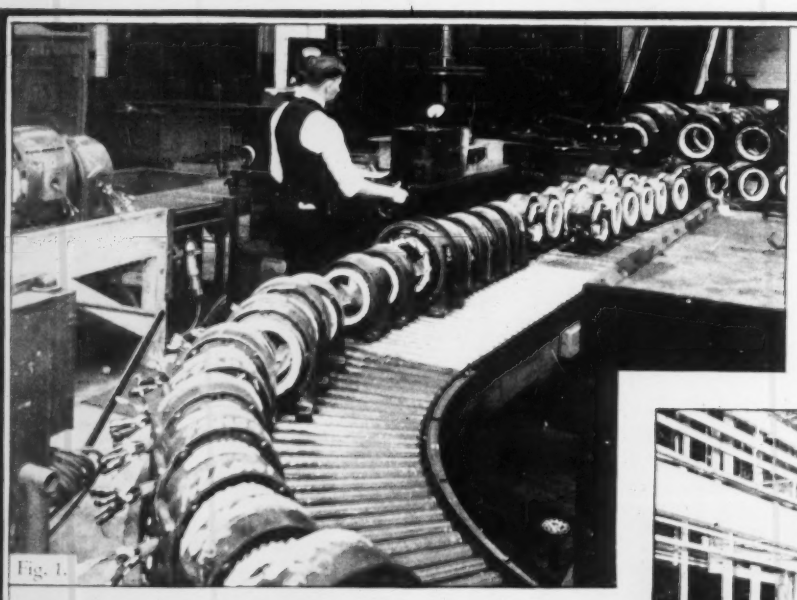


Fig. 1.

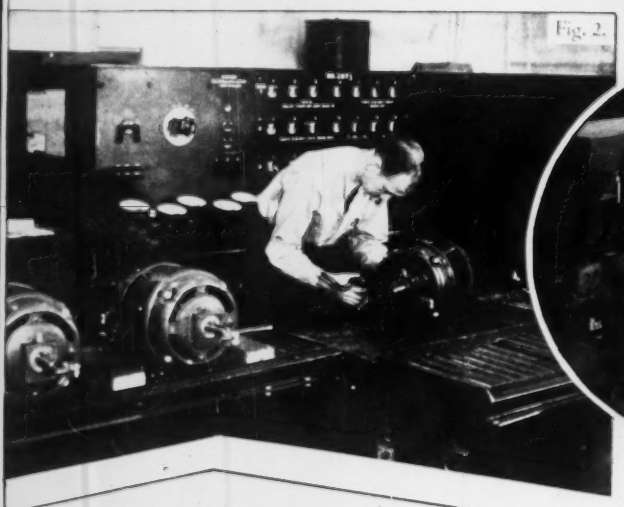


Fig. 2.

Fig. 3.

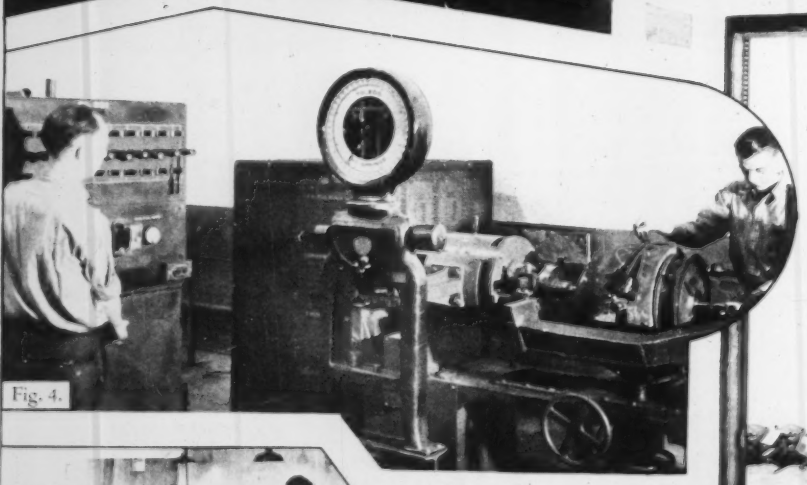


Fig. 4.

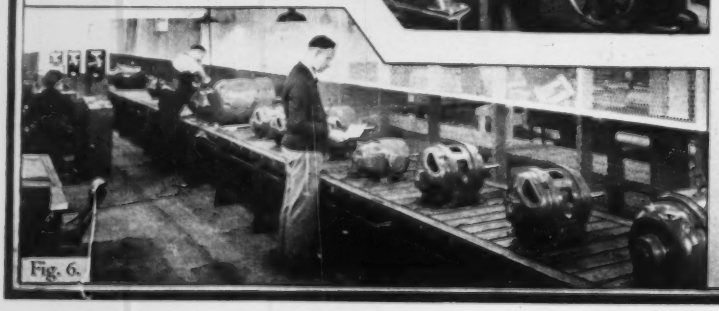


Fig. 6.

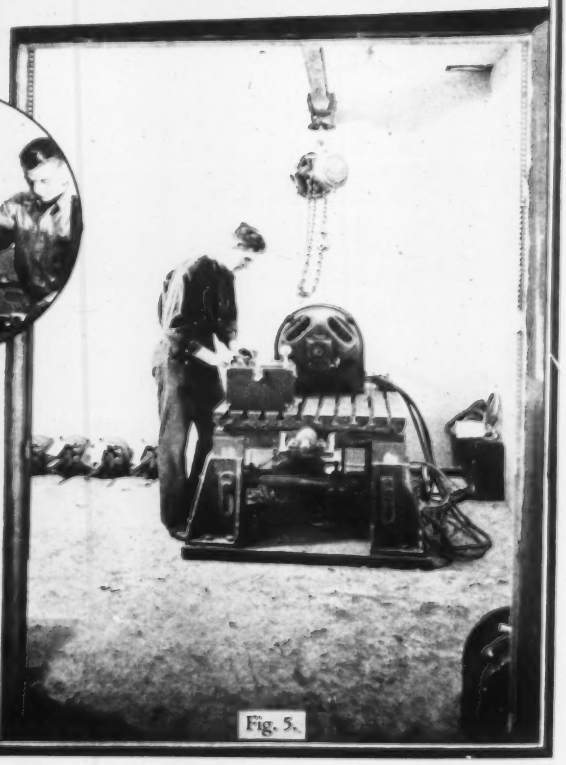


Fig. 5.

Fig. 1. High-frequency testing of stator windings.

Fig. 2. Final test on industrial a-c. motor. Note instrument table right behind operator.

Fig. 3. General view of test floor for "special" motors.

Fig. 4. Dynamometer test stand for input-output testing.

Fig. 5. Sound-proof room for noise-level measurements.

Fig. 6. Final inspection and fitting before shipping.

Instruments for Production-line Tests of Motor Windings and Assembled Motors

By W. H. HALEY

General Tester, Motor Division, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.

IN the new a-c. motor aisle, which is arranged to manufacture a-c. motors from 1 h-p. to 50 h-p., the testing facilities are divided into four groups: (1) Testing of stator windings; (2) "Commercial" tests; (3) "Engineering" tests, and (4) Special noise test.

TESTING STATOR WINDINGS

The useful life of an a-c. motor being largely dependent upon the quality of its insulation, induction motor windings are tested between each turn of wire with what is known as the high-frequency test (Fig. 1). A high-frequency test voltage (many times normal) is applied directly to the motor terminals, corresponding closely to the regular ground test of the A.I.E.E. Standards. This test is additional to those specified by the A.I.E.E. rules. It is made as soon as the windings have been connected, thus eliminating all defective windings before the motors are dipped in varnishes and baked.

The equipment comprises a high-voltage transformer which charges a capacitor so that it arcs across a rotating gap each half-cycle, discharging across this gap into an oscillating circuit of which the motor winding under test is used as an inductance which gives resonance. The frequency of oscillation is controlled by the inductance of the motor winding, since the capacitance in the circuit is fixed. The setting of the rotating gap determines the voltage applied to the winding. A pick-up coil is attached to a wave-meter and a thermocouple milliammeter is used as a resonance indicator. Each motor winding has a definite setting on the wave-meter (like tuning in a radio).

Errors such as wrong number of turns, reversed coils, reversed groups, wrong throws, wrong groupings and shorted coils—all these change the inductance of the winding and hence are detected by the wave-meter and the milliameter.

The great advantage of this additional high-frequency test is that it detects any weak spots in the insulation before the motor is put in operation—an added assurance particularly desirable on important applications.

COMMERCIAL TESTING FACILITIES

Tests of assembled motors are divided into two classes, commercial and engineering. The former are made on all standard motors to verify (a) that electrical performance of the original design is duplicated, (b) that mechanical operation is correct and (c) that insulation is adequate. All these commercial tests are made directly in the assembly line. There are four such lines in the new aisle; the motors on any one line are similar mechanically but cover a wide range of voltages, phases, frequency and horsepower. Therefore, the test equipment in each line must be flexible. It consists of three items (Fig. 2):

(1) A steel table set in the conveyor line, on which the motor rests while being tested. On this table are the leads for supplying power to the motors, control pushbutton and contactors for starting and for inserting the instruments in the circuit. The contactors are interlocked so that the instruments cannot be connected into the circuit until the motor is brought up to speed, thus preventing damage from high starting current.

(2) The metering table, with three ammeters, a voltmeter and a polyphase wattmeter. The ammeters and the current coils of the wattmeter are connected to multi-tap current transformers by means of a tap-changer, which changes the transformer ratio simultaneously in all line leads. The voltmeter and potential coils of the wattmeter connect to multi-tap potential transformers by means of ratio selector switches. There is a phase set-up switch to shift the potential circuit on the wattmeter for measuring 1-, 2- or 3-phase power. This arrangement permits rapid metering of the power input over a wide range of motor ratings.

(3) A plug board mounted adjacent to the metering deck, with receptacles connected to all "standard" voltages and frequencies, so that any voltage can be readily selected to suit the motors being tested.

FACILITIES FOR ENGINEERING TESTS

Engineering tests are made on all new designs, on standard motors after any changes in materials or processes, and also at frequent intervals on standard motors to verify their uniformity. Fig. 3 shows the floor section where these tests are made. It is called the "special motor" test floor. The most essential element in conducting these engineering tests is an adequate power supply. This is described in detail in Appendix A.

On the distribution board are located the controls for all motor-generator sets, regulators and breakers; and instruments for indicating voltages and load on the various units. The secondaries of the power supply transformers, the primaries and the secondaries of set-up transformers and regulators, and the armatures and fields of all generators terminate on this board. Individual circuits from this board connect to each test position; this permits *any* power supply apparatus (see Appendix A) to be connected to *any* test position on the floor. Moreover, the control circuits are so arranged that the control of any regulator or field of any set can be relayed from the main board to any test position *and operated at that point*.

CLASSES OF ENGINEERING TESTS

The majority of engineering tests are divided into four classes: (a) temperature tests, (b) performance curves, (c) locked rotor tests and (d) no-load losses.

(a) For temperature tests there are six positions on the floor, with apparatus adequate for the full range of motors manufactured. At each position is:

(1) A table to which the motor is fastened and the top of which is adjustable for belt tension. The motors are belted to d-c. generators which are loaded into resistance racks for the small motors, and loaded back into the d-c. power supply for the larger sizes.

(2) A metering table to measure the power input to the motor. On this table are the controls for both motors and for loading generator.

(b) For performance curves on induction motors the electrical input is measured by a metering table similar to the table used on commercial tests; and the mechanical output is measured on an electrical dynamometer.

The dynamometer (Fig. 4) is simply a generator with its frame mounted in bearings and so arranged that its rotational force is measured by a platform scale. All power delivered by the generator, and its losses, react on the stator to produce torque, which is registered by the scale.

The bearings supporting the frame are double: one fitting inside the other. To the two ball-bearing races which are mounted together is attached a ring gear driven by an auxiliary motor. The races at the two ends of the frame are rotated in opposite directions to eliminate friction errors.

Dynamometers of this construction range from 2 to 75 h-p. There is also one 20-h-p. cradle dynamometer, its frame mounted in a cradle supported by knife edges. It is more accurate than the conventional type, but slower to read.

Continued on page 418

A Portable Photoelectric Timer

By FRANCIS C. MOREY
Junior Physicist, National Bureau of Standards

Publication approved by the Director of the National Bureau of Standards of the U. S. Department of Commerce.

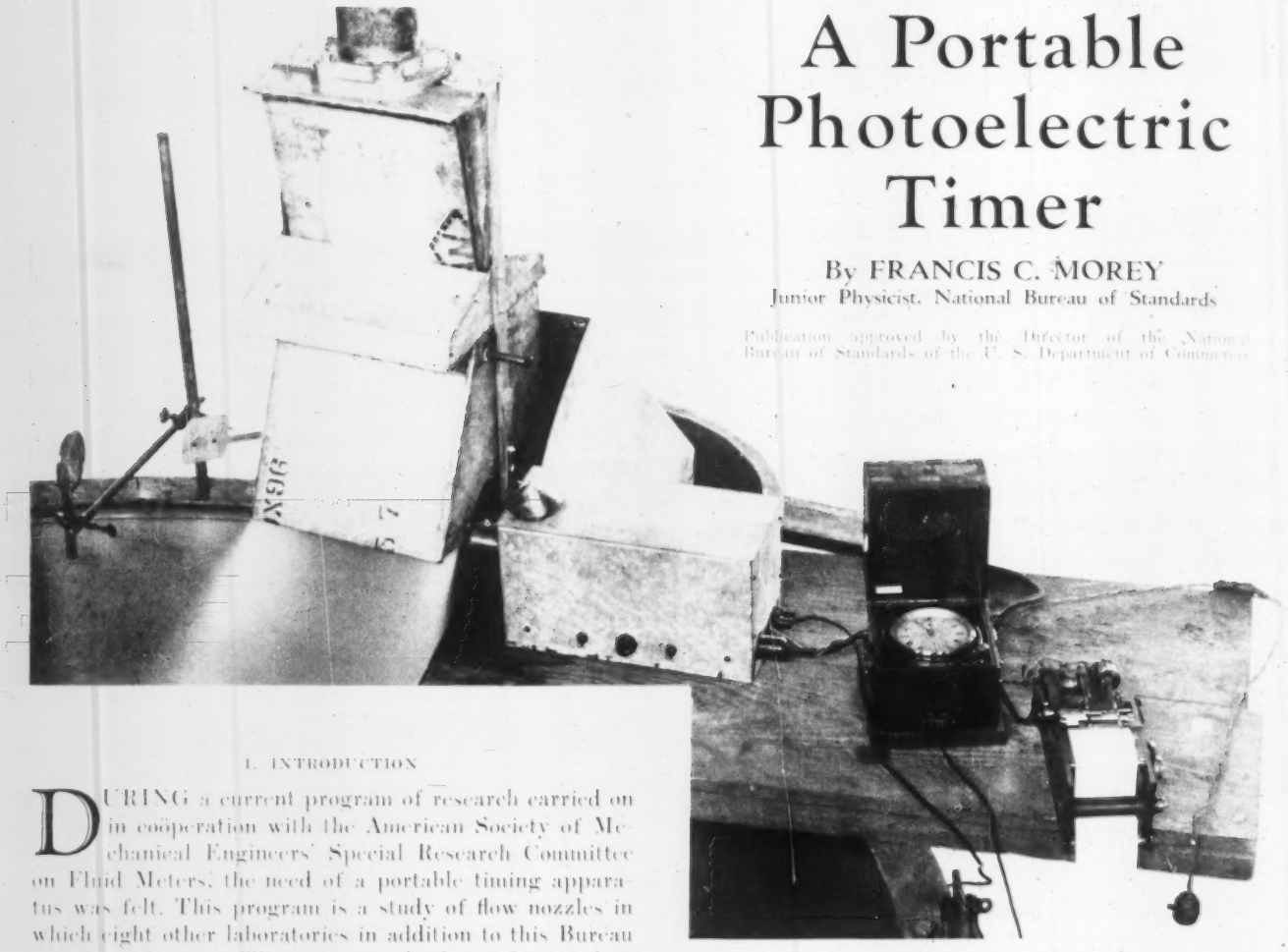


Fig. 1

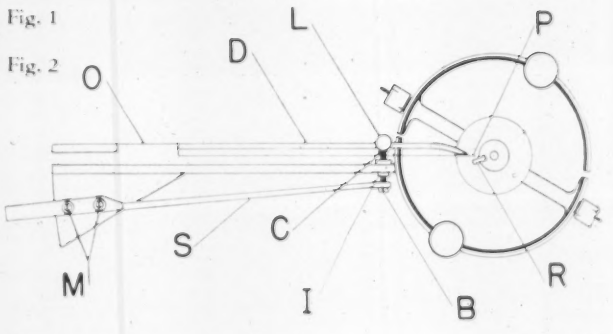


Fig. 2

I. INTRODUCTION

DURING a current program of research carried on in coöperation with the American Society of Mechanical Engineers' Special Research Committee on Fluid Meters, the need of a portable timing apparatus was felt. This program is a study of flow nozzles in which eight other laboratories in addition to this Bureau are participating. The tests involved in this project necessitate the direct determination of mass rates of flow by observing mass and time. To obtain precision of the time measurements, and to standardize time observations in the coöperating laboratories, the photoelectric timing apparatus herein described was built. The features desired in the timer were:

1. Overall accuracy of at least ±0.1 percent.
2. Range of a few seconds to a quarter of an hour or more.
3. Elimination of the personal "reaction time" factor.
4. Portability.
5. Ease of adaptability to various types of apparatus.
6. Permanence of record.

In addition to meeting these requirements the equipment constructed can be modified and extended so as to simultaneously time several different operations.

The primary source of time signals consists of a high grade ship's chronometer specially equipped with electrical contacts, supplying half second signals. These impulses are conveyed, through an electronic relay, to one pen on an electrically driven tape chronograph. A photoelectric relay, connected to another pen on the chronograph, provides the signals whose intervals are to be measured. The equipment thus consists of three parts: the chronometer, the electronic relays and the chronograph, and will be described in this order. Fig. 1 is a photograph of the assembled timer, ready for use.

II. THE CHRONOMETER

The chronometer was selected as the source of time signals after careful consideration of several other sources. It was felt that dependence on the commercially regulated a-c. sources might not provide sufficient accuracy over short intervals. Radio reception of standard frequency broadcasts was discarded because of uncertainties in their reception in various locations, and in the operation of frequency-changing circuits. The chronometer, however, furnishes a source of time signals the accuracy of which is appreciated by the layman as well as by the laboratory technician.

After a thorough cleaning and conditioning the timepiece was furnished with a pair of electrical contacts. Fig. 2 shows how these contacts were attached to the chronometer so as not to interfere with its operation. The banking screw *B* which adjusts the depth of engagement of the locking pallet in the escape wheel was removed and a piece of platinum soldered to its end. The tapped hole for this screw was then drilled out and an ivory bushing *I* fitted and tapped to take the screw, thus insulating it from the frame. A new spring member *S* was made and attached to the frame with insulated screws *M*. This spring serves to carry the current to the contact and also exerts an outward force on the banking screw, which holds the ivory bushing in position in its mounting hole.

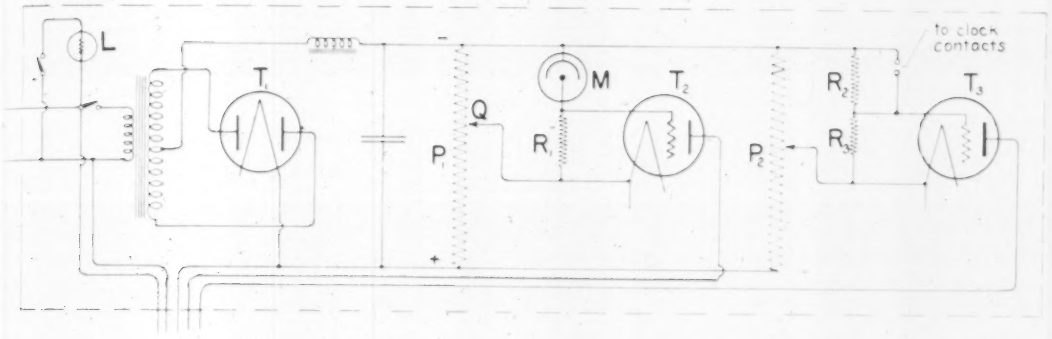
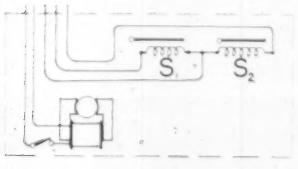
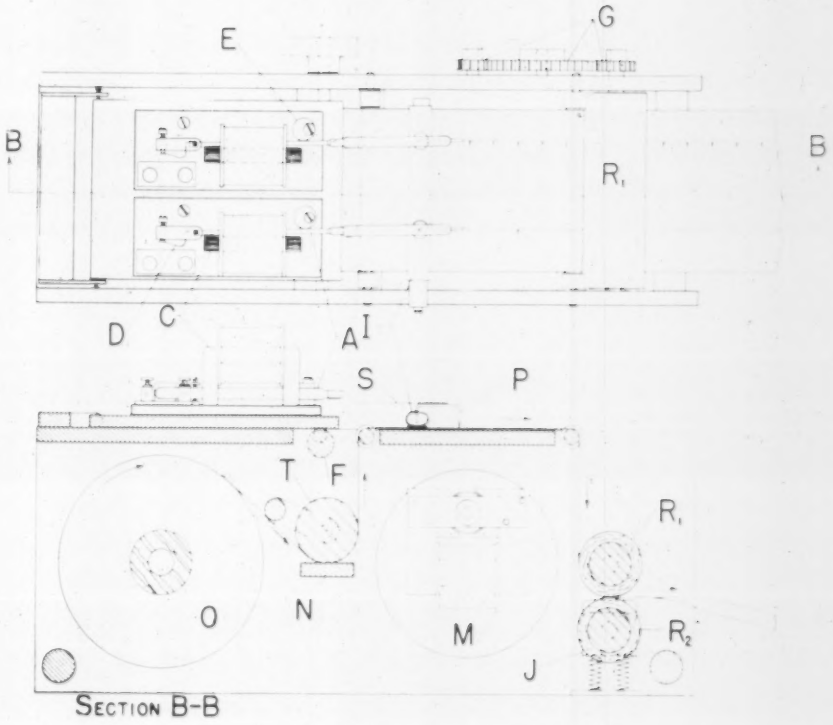


Fig. 3



The other platinum contact was soldered to the small steel boss *L* which carries the locking pallet jewel on the detent *D*. The banking screw normally rests against this boss, so that the contact is closed. When the discharging pallet *R* lifts the detent it breaks this contact. This break is sharp because it occurs nearly at the center of travel of the discharging pallet where the velocity of the latter is highest, and its motion at the point of contact is about normal to the axis of the detent. The only weight added to the moving parts is that of the small square of platinum mounted on the locking pallet boss. Since this weight is small and is not added to the time-regulating element, it cannot affect the accuracy of the timepiece. The electric current, which is only a few microamperes, does not pass through any of the rotating staffs or sliding parts, insuring low resistance and positive contact.

Fig. 4



SECTION B-B

III. THE PHOTOELECTRIC CIRCUIT AND ELECTRONIC RELAYS

The vacuum tube circuits, Fig. 3, consist of three divisions: the rectifier, the photoelectric relay and the time signal relay. The rectifier, of the full-wave type, is entirely conventional and needs no description here. It maintains about 300 volts across the potentiometers, P_1 and P_2. This is used to provide the plate voltages and grid biases of the type 45 amplifier tubes used as electronic relays for the photocell and the chronometer.

In the photocell circuit the cell *M* is normally illuminated, and its relatively low resistance keeps the grid bias of the amplifier tube at cut-off. However, when the light beam is broken, the dark-resistance lowers the grid bias and permits the plate current to flow to the recording pen. The pens require only about 15 milli-amps. for positive action. The photocell lamp *L* is a 50-watt 120-volt tubular motion picture projection bulb mounted in the amplifier case and provided with a collimating lens. The beam is directed away from the amplifier case and is returned to the photocell by means of a 3″ concave mirror, which helps to keep the beam concentrated.

The chronometer relay operates similarly. The clock contacts, normally closed, keep the grid bias at cut-off. At the break the grid bias drops to about one-fourth its former value owing to the insertion of resistor R_3 into the grid circuit. The current through the clock contacts is kept down to a few microamps. at all times by the one megohm resistor R_3. This practice insures long life of the contacts and smooth positive operation at all times.

IV. THE CHRONOGRAPH

The chronograph, Fig. 4, is of the moving tape type, and utilizes ordinary adding-machine paper. The motor *M* is a small shaded-pole induction motor with a built in gear reducer, the driving shaft of which rotates at about 20 rpm. A set of change gears *G* is supplied between the motor shaft and the driving roller *R*, giving three paper speeds of about $\frac{1}{4}$″, $\frac{1}{2}$″ and 2″ per second as desired. Driving roller R_1, approx. 1″ diam., is a steel shaft over which was pressed a section of rather stiff rubber tubing. This was then dressed round in a lathe by hand filing. A similar roller R_2 mounted in journals *J* holds the paper tightly in contact with the driving roller. A steel tension roller *T* resting on plate *N* provides sufficient tension in the paper to make it lie flat on the pen bed.

The pens *P* are of monel metal tubing, about 0.7 mm. I.D., bent into a broad inverted U shape and tapering to a small aperture which produces a fine line on the moving tape. The pens are fed by capillary action from the ink reservoir *I*, which extends completely across the tape to permit long operation between refillings. The small openings through which the pens operate minimize evaporation and consequent thickening of the ink. The pens are mounted on the operating armatures by thin phosphor-bronze spring strips *S* which permit them to be lifted off the paper easily, and supply light pen pressure, yet are rigid in lateral motion, so as to move the pens across the paper as the impulses are received.

In order to avoid the use of intermediate relays which might introduce time or operating uncertainties, it was decided to design the pens to operate directly from the vacuum tube relays. The magnet coils were wound on laminated cores C about 1" long and $\frac{1}{4}$" square in section. End pieces were constructed of the same material so as to interlock with the cores of the coils in the manner used in building up transformer cores. The finished magnets each consist of a rectangular U-shaped core with the coil wound on the bottom part of the U. The coils are wound with No. 40 silk-enamel insulated wire and have a resistance of 1200 ohms each.

The armatures A which move the pens were made of soft iron $\frac{1}{8}$" × $\frac{1}{4}$" in section. These were mounted at one end in cone pivot bearings. The operating magnets were fastened so that the armatures complete the magnetic circuits of the cores, resulting in a strong pull with currents as low as 8 or 10 milliamps. The best operating current was found to be about 15 milliamps. The armatures were provided with small phosphor-bronze restoring springs D of adjustable tension, and adjustable eccentric stops E of simple design to control the amount of displacement of the pens. The entire pen assembly was mounted on a pivoted base so that the pens can be elevated from the paper and ink reservoir, by means of the eccentric cam F, for inspection or cleaning.

V. OPERATION OF TIMER AND INTERPRETATION OF RESULTS

The procedure of operating the timer depends upon the length of the interval to be measured and the accuracy desired. The paper speed is first selected, depending upon the accuracy demanded. If the interval is short, up to a minute, the chronograph is allowed to run the full time of the test. For longer intervals it has been found convenient to determine the actual time of starting and stopping the test, so that the chronograph may be turned off during most of the run. To do this the operator makes a pencil mark on the tape identifying any convenient reference second, usually the sixtieth or the thirtieth second. The hour and minute are also noted on the tape. Then after the start of the interval has been recorded by the photocell pen the chronograph may be turned off until nearly the end of the period, when the same process is repeated.

The record which the chronograph tape supplies thus consists of two lines or traces, one of which records the half-second signals from the chronometer, and the other marks the beginning and the end of the test run. The former will be called the time axis, and the latter will be known as the event record. To interpret these records a draftsman's triangle is laid along one of the traces and with a hard pencil the beginning of the event is projected across onto the time axis. The time impulse just preceding and the one just following the event are similarly projected onto the opposite trace. Three fine pencil lines are thus obtained with the beginning of the event represented by the middle one. It is a simple matter to interpolate with the aid of an ordinary draftsman's scale placed diagonally across the pencil marks, and since the chronometer beats half seconds, using five divisions of the scale gives tenths of a second. Using the 2" sec. paper speed and fifty divisions of the scale, the scale divisions represent hundredths of a second.

When making accurate observations with the photoelectric timer it must be remembered that unless the beginning and end of the interval are sharply defined the record of the timer has no meaning. Thus in determining rates of flow of water it was first necessary to design a diverter which would change the flow of the water stream from the waste channel to the measuring basin in less than the time tolerance limits. Some idea of this uncertainty with any given set-up can be obtained by inspecting the chronograph record. Since the total restoring time of the time axis pen is found to be about 0.08 sec., if the event marks are broader than the time marks there is a proportionate uncertainty. The restoring time does not enter into the time axis measurements however, since the first observable displacement from the line is taken as denoting the time signal from the chronometer.

Tests were made on the timer after completion to determine the reliability of the apparatus. No special effort was made to secure the best possible performance of the chronometer, but it was wound at rather irregular intervals and by different persons, approximating the conditions under which the timer is used. The room temperature varied daily from about 10° C. at night to about 20° C. during the day time. Although the case of the instrument was kept closed except during observations, no other protection was used. The comparisons were made with time signals from a Riefler clock, distributed to the buildings at the Bureau over special wires through relays. These time signals are compared daily by radio with those of the U. S. Naval Observatory, and may involve only extremely small errors due to delay in the relays and variation in rate of the Riefler clock. Table I shows the results of a series of nine observations on the chronometer.

It will be seen from Table I that if the Riefler clock signals are considered as absolutely correct the maximum rate of gain is only 0.0198 second per hour, and the maximum deviation from the average rate of gain is 0.0158 second per hour. Thus the daily variation of the chronometer is negligible in the measurements in which it is used. For short-period variations four trials of sixty seconds each were made on different days. Table II shows the results of a second-by-second comparison.

In this analysis it must be remembered that the figures include all the errors of the chronometer and chronograph combined, and of the relays of the Riefler clock system, as well as those introduced by interpolating the times on the paper tape from the chronograph. Thus if we consider the Riefler clock signals as absolute, as is probably justified, the percentages indicated in the last column indicate fairly well the accuracy expected in short runs of the chronometer and chronograph.

In actual use in measuring the rate of flow of water the rate determination agree very well even when the time interval is quite short. Table III shows the results of eleven measurements during which the flow was held as nearly constant as possible with a constant-level tank.

TABLE I. COMPARISON OF CHRONOMETER WITH BUREAU OF STANDARDS TIME SIGNALS, FOR DETERMINING DAILY RATE.

Riefler Clock Signal h m	*Chronometer Time* h m s	*Riefler Interval* h m	*Chronometer Interval* h m s	*Rate of Gain* sec./hr.	*Variations From Average* sec./hr.
9:31	9:30:55.02				
1:34	1:33:55.10	4:03	4:03±0.08	0.0198	0.0142
5:38	5:37:55.82	24:59	24:59±0.72	0.0288	0.0052
1:15	1:14:56.95	22:42	22:42±1.13	0.0498	0.0158
10:41	10:40:57.80	21:26	21:26±0.85	0.0397	0.0057
12:00	11:59:59.59	49:19	49:19±1.79	0.0363	0.0023
11:36	11:36:01.07	47:36	47:36±1.48	0.0311	0.0029
3:09	3:09:01.20	3:33	3:33±0.13	0.0366	0.0026
1:23	1:23:01.91	22:14	22:14±0.71	0.0319	0.0021
9:59	9:59:02.56	20:36	20:36±0.65	0.0316	0.0024
			Average	0.0340	

TABLE II. COMPARISON OF TIMING APPARATUS WITH BUREAU OF STANDARDS TIME SIGNALS, FOR DETERMINING SHORT PERIOD ERRORS.

Trial Number	*Maximum deviation, chronometer behind Riefler signal* sec.	*Maximum deviation, chronometer ahead of Riefler signal* sec.	*Maximum Percent error for 60 second run*
1	0.010	0.015	0.042
2	0.012	0.012	0.040
3	0.015	0.012	0.045
4	0.016	0.007	0.058

TABLE III. COMPARISONS OF MEASUREMENTS OF A CONSTANT RATE OF FLOW.

Run No.	*Mass of water* lbs.	*Time* sec.	*Rate* lbs./sec.	*Deviation from average rate*	*Percent deviation*
1	942.5	19.92	47.31	0.03	0.06
2	931.0	19.64	47.40	0.06	0.13
3	970.5	20.49	47.37	0.03	0.06
4	883.8	18.67	47.34	0.00	0.00
5	862.8	18.21	47.38	0.04	0.08
6	817.2	17.28	47.29	0.05	0.11
7	817.2	17.26	47.35	0.01	0.02
8	703.0	14.86	47.31	0.03	0.06
9	692.2	14.62	47.35	0.01	0.02
10	35.2	7.535	47.27	0.07	0.15
11	426.0	8.998	47.34	0.00	0.00

Modern Scratch Hardness Methods

Twelfth instalment of "Hardness and Hardness Measurements." See page 1, Jan. 1937 issue

By S. R. WILLIAMS
Professor of Physics, Amherst College

BIERBAUM'S STANDARD INSTRUMENT—

(Continued)

In a description of the microcharacter and its use as an instrument of measure, given in the Metals Handbook[1], the following precautions are suggested: "The diamond, the hardest of all known substances, is brittle. Under no condition should the point of this diamond be brought in contact with another diamond, since an almost insensible pressure upon the exceedingly sharp point produces a load per unit area that is far in excess of the crushing strength of the diamond. It should not be subject to blows of any kind during manipulation. The instrument is not intended for commercial testing; it is for research only, in the hands of a skilled metallurgist or microscopist."

One of the above items contains a factor which should be kept in mind when one is using a scleroscope in which the load on the diamond is a measure of the hardness. What will happen to a diamond's cutting edge if enough load is put on it so that it will cut a groove wide enough to match the standard width when the substance tested is almost as hard as the diamond itself? Just in this range of load on the diamond lies another question as to how plastic is the permanent deformation when a load is added until a certain scratch width is attained? It is conceivable that for small loads and narrow cuts the trace left by the diamond edge would be a plastic deformation, whereas for heavy loads and wide cuts abrasion might easily occur. If extra load starts a diamond to ploughing (abrading) there is no hope of consistent results, because, as has been indicated, abrasive and plastic processes are different.

MICROSCOPE FOR MEASURING WIDTH OF MICROCUTS

For measuring the width of the microcut one needs the best of microscopes. The one recommended by the manufacturers of the Microcharacter has its parts listed as follows:

(a) Monocular Body Tube
(b) Plain Rectangular Stage
(c) Objective Holder
(d) Quick Change Objective Carrier with four objective rings
(e) Short Mount Archromatic Objectives,
Objectives, 32 mm. dry
16 " "
4 " "
No. 127 M, 1.8 " oil immersion, N.A. 1.
(f) Huygenian Oculars 6× and 10×
(g) Vertical Illuminator
(h) Micrometer Eyepiece

Some may wish to have other accessories beside those listed above. For instance, those working with a group of hard materials may desire greater magnification.

CHARACTER OF CUT MADE BY DIAMOND EDGE

Various references have already been made to the character of the mark produced by various hardness testers, both of the scratch and the static penetrating type. If hardness is resistance to permanent deformation, it is evident that the resulting deformation may be by abrasion or it may be of a plastic type.

When the corner of a file makes a notch in a piece of glass tubing, preparatory to breaking off a piece, the scratch is distinctly an abrasive process. On the other hand if the polished edge of a sharp knife is pulled along the surface of a mass of putty a permanent groove remains, but no putty has been removed in the process. The mechanics of the two processes are distinctly different.

The question now arises,—to which one of these two processes does the microcut of Bierbaum's instrument belong? Fortunately, this point has had some study made of it, and the author hopes before long to make a similar study of the scratch or cut made by other types of sclerometers.

Figs. 71, 72, 73 and 74 show how the microcuts for various substances appear under the microscope. In an

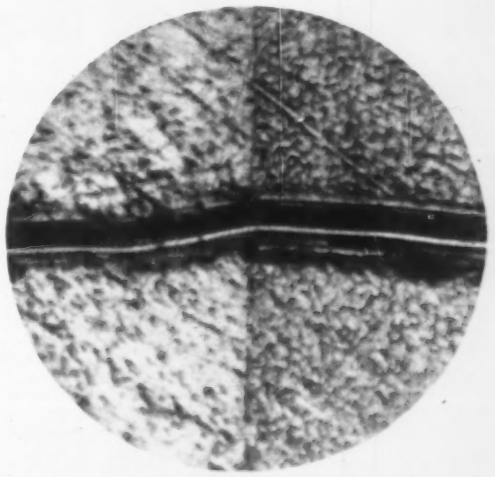


Fig. 71. Microphotograph showing how the microcut looks when the diamond edge moves from one grain to another. Microcut across the surface of a chemically pure piece of copper, showing the isotropy of copper. Magnification 1000 ×.

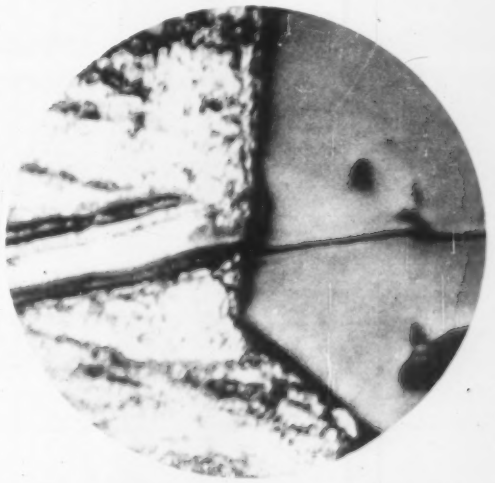


Fig. 72. Microcut across a piece of bronze in which is imbedded a crystal of tin oxide. This shows a distinct difference between the hardnesses of the two materials. Magnification 1000 ×.

[1] C. H. Bierbaum. The Microcharacter. Metals Handbook, 1939 Edition, pages 33-34. The American Society for Metals, 7016 Euclid Avenue, Cleveland, Ohio.

article by Conley, Conley, King and Unger[5] there are shown the microcuts made by a microcharacter in the surface of tin. Both are taken at a magnification of 1570 ×. Fig. 75(a) shows the microcut as viewed normally, while Fig. 75(b) is a cross sectional view of the same microcut. When the knife edge goes through the soft putty there is a slight rising of the surface on both sides of the cut (ridges). Those particles which formerly occupied the space now possessed by the cut had to go some place and so a small lifting of the surface of the putty on both sides of the cut occurred which would account for this change in the space occupied by the cut. In Figs. 75(a) and (b), this lifting of the surface

Fig. 73. Microcut across a zirconium nitride crystal. The crystal is nearly 1 5 of a thousandth of an inch. Magnification 1000 ×.

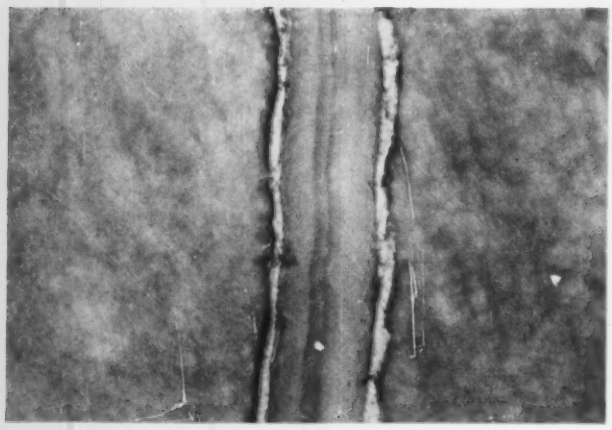


Fig. 74. Microcut in tin at a magnification of 500 ×. Looking at the cut in a direction at right angles to the surface. (Conley, Conley, King & Unger.)

on both sides of the cut in a surface of tin is proportionally much larger than for putty. Tin cannot be compressed a great deal and so ridges are thrown up on both sides of the cut, but no actual removal of material is effected. In this sense of the word the microcut is a real cut and not an abrasive process.

It is quite conceivable, however, that in certain brittle substances the edge of the diamond might actually shear off parts of the surface. Thus in the microcut on a calcite surface, shown by Hodge and McKay[6], it would appear that just this sort of thing had happened. Even here if a smaller load on the diamond edge had been used no such abrasion would have occurred. For a given substance and a given diamond edge or indenter there is a critical load beyond which a cut becomes a scratch (abrasive).

In the paper by the Conleys, King and Unger will be found a microphotograph showing that the width of the microcut will depend upon whether the microscope is focused on the surface of the specimen or upon the tops of the ridges. A similar effect was found by O'Neill[7] in measuring the diameters of the indentations produced by a Brinell hardness tester. Not only will position of focus be a factor, but as O'Neill shows, the direction of illumination change the apparent diameter of the impression. Talmage in studying the Graton sclerometer established the direction of illumination of the scratch as one of the standard conditions for making measurements with the instrument.

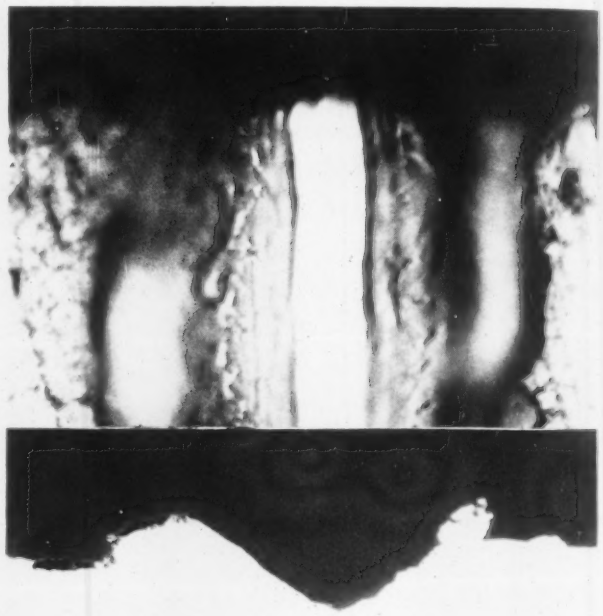


Fig. 75. (a) Top view of cut on tin at a magnification 1570 ×. (b) At the same magnification is shown a cross-sectional view of the same microcut.

Width of scratch or of indentation brings up another outstanding question,—is the imprint of a cutting tool or the impression of an indenter to be measured by its width or diameter or is depth the most accurate gage?

The ridge along each side of the microcut makes the cut a continuous indentation process. In discussing this form of hardness testing in subsequent articles it will be pointed out by means of a model how this piling around the edge of an indentation occurs. There is need for further study of the character of the edge of the mark when an abrasive cut is made and also of the edge of an impression when a diamond indenter is used on hard, brittle substances. There may be a need for making a more specific distinction between brittleness and plasticity in the measurement of hardness.

Continued on page 318

[5] W. J. Conley, W. E. Conley, H. J. King & L. E. Unger. The Microcharacter as a Research Tool. *Transactions American Society for Metals*, Vol. 24, 1936, pages 721-734.

[6] H. C. Hodge & J. H. McKay. The Microhardness of Minerals Comprising the Mohs Scale. *American Mineralogist*, Vol. 19, 1934, pages 161-168.

[7] H. O'Neill. Note on the Diameter Measurement of Certain Brinell Indentations in Cold-rolled Metal. *Journal Institute of Metals*, Vol. 46, 1931, pages 267-272.

Cathode-ray Oscillograph Applications

Twenty-eighth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

AUTOMOTIVE TESTS
(*Addendum*)

Fig. 6a is a sketch showing the construction of a pressure unit developed by RCA Mfg. Co. for use in studies of gas and diesel engines, pumps, etc. This unit must be mounted so that its inner face is within the cylinder itself and locked in position by locknuts (L). This unit uses the quartz type of piezo crystal and so can be used at temperatures up to around 650° F. Two crystals (G and I) are mounted back to back, with an intermediate electrode (H) to collect the potentials generated. The outer faces of the crystals are grounded, through the electrodes (F) and (J). Fixed pressure is applied to the crystals by the nut (E). A connection to the center electrode is made through rod (C) from the cable.

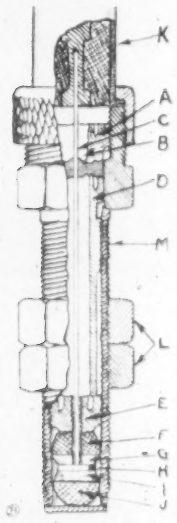


Fig. 6a

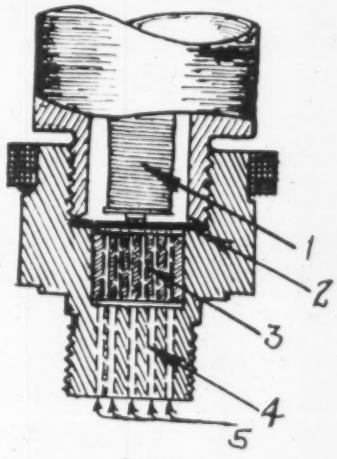


Fig. 6c

A system recently developed in Great Britain uses a somewhat different technique.* Three items of special interest are:

(1) the pick-up unit, which inherently develops output voltages proportional to the rate of change of the applied pressure, and therefore gives a curve which is the differential of the pressure-time curve;

(2) the integrating circuit, incorporated in the amplifier, which enables the pressure curve as well as the rate of change curve to be delineated as desired, giving either displacement or pressure diagrams, and

(3) a calibrating unit which can be operated in place, without disturbing the normal connections and at the same time is free from contact and seat area troubles. It is possible to obtain a dynamic calibration as well as a static one.

The pick-up unit, Fig. 6c, consists of a small open core magnet (1) mounted axially within the housing of the unit. The center of a magnetic diaphragm (2) of suitable flexibility moves up and down near the pole of this magnet and creates a disturbance in the magnetic field. It has been calculated that the change in flux through the core of the coil is only ± 5 lines of force but this is sufficient to produce the required deflections, due to the amplifier. A small emf. is thereby induced in the coil and is applied to the input of the deflection amplifier. The diaphragm is extremely stiff; it has a natural period of over 50,000 cycles, and moves less than 0.0005" when it is actuated by the pressure of the gases, when the unit is placed in the cylinder wall through a suitable opening. The gases, however, reach the diaphragm through a series of two passageways (3) and (4) in tandem, each with several specially shaped openings (5) which serve to damp any oscillations in the gas flow, prevent false operation due to sound waves, and assist in keeping the diaphragm cool. This multiple passageway (3)and (4) to the diaphragm was developed as a result of elaborate tests dealing with the elimination of numerous ripples and resonance effects due to gas oscillations in the passage.

A similar unit modified for higher pressures and arranged so that it can be installed on fuel line systems, indicates pressure variations and also residual values.

To be continued

*The following material describes the developments of Messrs. Beale and Stansfield, made in cooperation with Standard Telephone and Cables, Ltd., and the Anglo-Iranian Oil Co., Ltd., and represents a portion of the information privately communicated by Mr. E. S. Beale of London. See also References 9A, 9B and 9C.

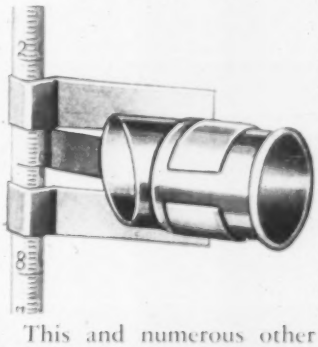
9A Beale and Stansfield, The Standard-Sunbury Engine Indicator, *The Engineer*, Vol. 160, 1935, pages 617-619, 642-644, 667-669.

9B Beale and Stansfield, High-speed Engine Indicators, *The Engineer*, Vol. 163, 1937, pages 240-241, 270-273.

9C Le Mesurier and Stansfield, Vibration in Engine Structures, *Transactions Institution of Engineers and Ship Builders*, Vol. 53, 1937, pages 223-246.

THERMOMETER AND BURETTE READING DEVICE

Indispensable in the laboratory for quick, accurate reading of thermometers, burettes, etc. Consists of lens magnifying 5.5 times over a field of 22 mm., held in tube with an extension serving as a reflector for illuminating the object. Tube fitted with spring clamp, operated by a small lever. Will fit tubes from 4 to 15 mm. in diameter, and is easily adjustable to desired position.



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INSTRUMENTATION FORUM

PROBLEMS — SOLUTIONS — DISCUSSIONS

OCTOBER PROBLEM (No. 12)
RECORDING SURFACE PROFILE

"In lithography from metal plates, the surface of the plate is 'grained' to give a rough matte finish. Our present methods of measuring our results are microscopic and photo-micrographic inspections. Only one quantitative method has been proposed: spreading a known volume of a dye solution and measuring the area it covers. An instrumental method is needed.

"Thinking of the grained surface as more or less uniformly spaced hills and valleys, maximum height about 0.0005", its profile might be measured by 'playing' an area with a phonograph needle, and measuring the resulting pitch and volume to obtain frequency and amplitude (number and height of the hills). A more direct method would be to pass a fine point over a straight line of given length, magnify the motion and record it on a chart. Possibly some optical method might be used although the surface variations are large compared with light waves. To be adopted, a method should involve the use of commercially available instruments and — if possible — auxiliaries."

85 PRIZE SOLUTION
By E. M. FRY, JR.
ROSELLE PARK, N. J.

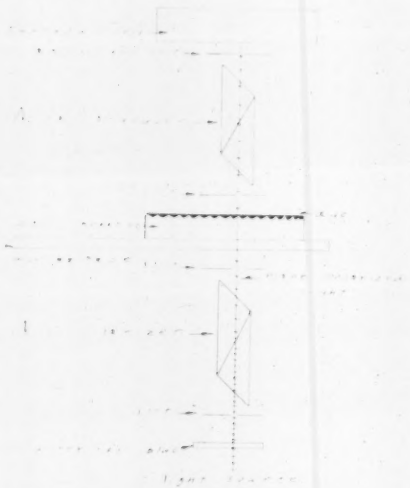
Equipment required: (1) laboratory press; (2) photoelectric potentiometer, such as Weston Model 721; (3) Leeds & Northrup Micromax single-point recorder; (4) densitometer, such as Bausch & Lomb, Gaertner, etc. This densitometer is the *recording* type used in spectroscopy. It comprises a light source which shines through a developed photographic plate to a photocell operating a mirror galvanometer through a suitable amplifier. A second light source shines on the galvanometer mirror and thence on an undeveloped plate which is attached to the same table as the developed plate. The table is driven by a synchronous motor through a gear reducer and lead screw. Variations in intensity of the lines on the developed plate are plotted as differences in the "y" coordinate of the record on the undeveloped plate (which is developed after the determination is run).

The sketch shows the essential part of the instrument modified for our purpose.

Materials required: (1) A clear plastic or gelatin which can be pressed on the grained plate and produce an accurate negative; (2) a liquid dye which ideally has the same index of refraction as the gelatin and which has good "wetting" qualities so that it would flow to the bottom of the grooves.

Procedure: The light source is turned on and allowed to come to a stable condition. The filament voltage should be set to a standard value. A negative of the grained metal plate is made by placing the plastic on the plate and applying pressure. (Exact pressure for a clear impression determined experimentally.) This negative is placed in the holder in the modified densitometer and the dye spread over the surface. Then the synchronous motor driving the densitometer is turned on, and the recorder is turned on. A trace will be obtained on the recorder chart which will represent the profile of the matte surface, highly magnified.

Discussion: The electrical hook-up consists simply of connecting the output of the photocell to the input of the photoelectric potentiometer and the output of the potentiometer to the L&N recorder.



The filter is placed after the light source to minimize the diffraction which takes place at the edge of the slits. The Nicol polarizer, adjusted so that the light is plane-polarized at right angles to the grooves, eliminates polarization which might take place at the surface between the negative and the dye (two materials having exactly the same index of refraction might be hard to obtain). The adjustable slit is adjusted to give maximum clarity to the trace on the recorder.

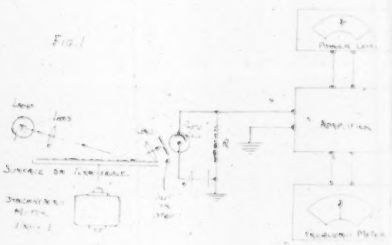
The densitometer and the recorder being driven by synchronous motors connected to the same source, the mechanical feed ratio in inches per hour divided by inches per hour could be set by design. A ratio of 100:1 or 1000:1 can be easily obtained. For example if the grooves have their crests 0.0[illegible] apart and a ratio of 1000:1 was used then when the densitometer table traveled the width of a groove (0.000[illegible]) the recorder chart would have traveled 0.5". Any convenient ratio can be chosen.

To obtain the exact grain-depth magnification on the recorder chart — in other words, to calibrate its depth coordinate — extensive data would have to be taken. However, if reference charts calibrated in length but not in depth were made on satisfactory sample (founded by experience to give good results in lithography) and catalogued, the routine records made on plates could be easily compared with the reference charts and the quality and press life of the plates predicted.

85 PRIZE SOLUTION
By L. RICHARD LANKES
ROCHESTER, N. Y.

The published statement of the problem included suggestions for two methods which might prove feasible.

One method, using a needle for "playing" a portion of the surface and thereby obtaining a measurement of the resulting pitch and volume (or frequency and amplitude), could probably be carried out more successfully by using a photocell scanning system in preference to a needle and phono pickup. Needle scratch would doubtless mask and seriously interfere with measuring the fundamental frequency as well as amplitude. As indicated in Fig. 1, a parallel-beam light



source could be set up at a fixed low angle with respect to the surface being studied. This would illuminate the portion being scanned by the photocell. The amplifier, in conjunction with the photocell, would supply the power for operating an electronic frequency meter and an output power-level meter, thus giving a direct indication of the two factors in question. A synchronous motor drive

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Problem No. 14 — Subject Index 2.99

RECORDING TIRE TRACTION EFFICIENCY

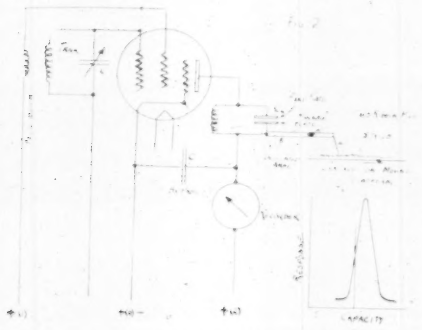
"Our Research Department plans a series of tests involving draw-bar pull of farm tractors, together with percentage slip of the tractor drive wheels at various values of draw-bar pull from zero to the maximum ability of the tractor. We desire to measure: (a) the slip of the wheel of the tractor. (b) the draw-bar pull of the tractor. (c) the rolling resistance of the tractor.

"The rolling resistance plus draw-bar pull represents the total input to the tires which we may call the total traction exerted by the tires. This is what we wish to study since slip is produced by the total thrust of the tires. Any method which gives continuous and instantaneous values of slip and total tire thrust will serve our purpose."

Five dollars will be paid for every solution (or critical discussion clearly pointing the way to a solution) which is accepted for publication. Address Instrumentation Forum, 1121 Wolfendale St., Pittsburgh, Pa. Type double-space, on one side of paper. Draw diagram in black ink on separate sheet. Mail before Jan. 15. Solutions and discussions accepted will appear in Feb. 1938 issue.

ould always accomplish a fixed speed d thereby correlate frequency directly gainst the number of surface etchings. he depth of the etchings would be deted in the modulation of the light aching the photocell and hence indited by the output power-level meter ith the amplifier always set for a given egree of gain. (The amount of light reected back to the cell would be affected y the depth of the etchings.) Instruents are commercially available for setng up this system. There are many ood amplifiers and power-level meters rom which to choose and there is an xcellent electronic frequency meter availble from a well-known and reliable firm.

The other method, involving the magnification of the motion of a fine point moved over the surface along a straight line of given length, should be carried out nicely by making use of an electronic high-frequency oscillator circuit. A suggested form appears in Fig. 2. Considerable information has been published under the title "The Ultra-micrometer" and similar headings. (Examples, Olken's thorough reviews in Feb. and May 1932 *Instruments*.) A light-weight stylus or



point is mechanically connected to move one plate with respect to another which is fixed. These plates constitute a small variable capacitor located in the output circuit of an electron-coupled oscillator whose frequency remains practically unaffected by changes in the output circuit. The output circuit is slightly detuned to the oscillator frequency so that, as the capacity changes, the actual output varies along the steep, straight-line portion of the resonance curve for this circuit. A recorder can be connected into this output circuit and a calibration effected between its reading and the stylus position. Excellent thickness gages have been set up this way capable of correctly indicating millionths of an inch. The recorder chart drive could be connected to the drive for moving the surface being studied, so that all charts could be compared on the same basis. This method, as opposed to the first, has the disadvantage of not being readily set up by merely connecting together commercially available instruments. It would also be subject to the possibility of errors due to the point or stylus not reaching properly into the depths of the etchings, the stylus chattering or catching on the peaks, or the stylus partly destroying or injuring the surface as it passes over.

85 PRIZE SOLUTION

By H. OLKEN
CAMBRIDGE, MASS.

Part I. *Frequency.*

For the frequency or concentration (number per square inch) of "hills," dust the plate with a fine white powder, then tap the plate so the fine dust will settle between the hills, leaving the hills a number of exposed dark dots. Photograph under some suitable standard conditions (intensity of incident light, time of exposure, type of film, etc.). Then pass the resulting negative under some film densitometer (many standard types on the market). The average density of the film will give a good figure of average density of the "graining" dots, in the plate area under study, which area may be a square, a long narrow strip (equivalent to a "line"), etc.

Part II: *Depth.*

To get a quantitative criterion of depth distributions take a lightly exposed X-ray photo of the plate under X-rays just intense enough to pass through the thinest parts of the plate (the deepest valleys) and make an impression on a film. The density of this film will be the greater, the more of these deep valleys per square inch. Hence it can also be read under the film densitometer. Next obtain another exograph with a slightly longer exposure, all other conditions being the same. This exposure will darken the film not only through the deepest valleys (say 0.0005") but also through the valleys not quite so deep (say 0.0004"). Measure the density of this film in the densitometer. The previous density reading subtracted from this reading will give a figure of concentration for valleys only 0.0004" deep.

(Instead of longer exposure, it may be necessary or preferable to use a higher intensity of the X-rays to show up the shallower valleys. This can easily be arranged by increasing the X-ray tube current or bringing the tube nearer the plate.)

Similarly, a figure corresponding to the concentration of the valleys 0.0003" deep can be obtained by subtracting the densitometer reading for the 0.0004" valleys from the densitometer reading for the exposure intense enough to penetrate the plate at valleys of only 0.0003" depth. The same type of fiure can be obtained for valleys 0.0002", then for those only 0.0001". One will then have a fairly good quantitative indication of the dispersion (or concentration) of valleys of different depths.

Of course more or fewer readings, of more or fewer depths, can be taken, depending on the accuracy desired. For instance, it may be desirable to have a figure for the average density of valleys at regular increments of depth in as many as ten, or as few as two steps between depths from zero to 0.0005".

The X-ray machine for this york may be simple, even smaller than such as dentists use. The densitometer and photographic equipment are standard supplies, available at most good photographic supply houses. The figures of point concentrations, and likewise the figures for concentration of different valley depths, being simple indications (indices) would constitute practical criteria.

85 PRIZE DISCUSSION

By W. H. DEWITT
ROCHESTER, N. Y.

A device on the market, the Brush Crystal Pen Recorder (Brush Development Co.), produces a record on a tape chart by a pen-arm attached to a Rochelle salt crystal which bends in proportion to the voltage impressed upon it. Voltages from direct current to 100-cycle a-c. can be used to operate the pen. It also is possible to generate a voltage by bending a Rochelle salt crystal. If such

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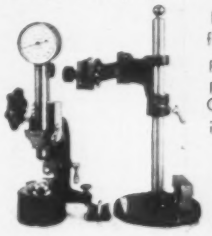

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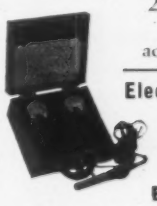

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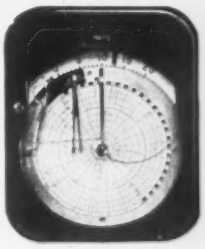

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a crystal pick up could be so arranged that its stylus would pass over the grained surface of the metal plate in a straight line, a voltage would be generated proportional to the variations of the plate surface. The voltage output of this crystal would then be fed into a suitable amplifier whose output would be sufficient to cause a motion of the recording unit's pen arm on the chart. The record thus obtained would be a true picture of the plate's profile in an easily readable form. The proper chart speed and "scanning" speed for the pen moving over the plate surface could be obtained by experimenting with satisfactory plates on hand. Since the maximum height of the "hills" is about 0.0005", the "scanning pen," which is glass, would probably have to be fitted with a suitable stylus similar to a phonograph needle.

85 PRIZE DISCUSSION
By CHARLES S. GARY
KENMORE, N. Y.

It seems that this problem could be solved by use of one of the numerous available reflectometers of gloss-meters. In this case, however, the instrument would be used to measure the lack of gloss. To make a complete analysis of the possibilities of solving the problem in this manner, one would need an instrument capable of measuring both the specular and diffuse reflection at varying angles of incidence and reflection.

If the writer understands this problem correctly, the surface of the lithographic plate is grained with emery or a similar abrasive. This would seem to eliminate the possibility of surfaces being geometrically similar and having the same reflection coefficient regardless of size of the abrasive with which they were ground. The postulate that geometrically similar surfaces have the same reflection coefficient is open to discussion, however, as it is probable that diffraction effects vary with depth of abrasions.

The preceding theory would indicate that the specular reflection would be the correct value to measure, but a measurement on two pieces of glass ground with numbers 302 and 90 emery respectively gave disappointing results, the glass ground with the 90 emery reflecting only 10% more light than that ground with the 302 emery. The angles of incidence and reflection in this experiment were approximately 70°. Varying these angles did not seem to increase this difference materially. Knowing from this result that it would not be practical to try to measure the difference in the reflection coefficient of surfaces ground with abrasives more nearly the same size than the two selected, it seemed advisable to determine what results a measurement of the diffuse reflections would give. Using the same angle of incidence but an angle of reflection of −10° it was found that the surface ground with the 302 emery reflected twice as much light as that ground with the number 90 emery. The negative angle of reflection in this case indicates that both angles are on the same side of the normal to the surface.

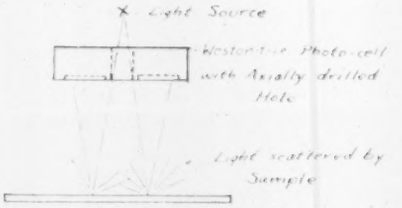
Although it was much easier to differentiate between surfaces ground with different grades of emery by measuring the diffuse reflections, a glossy spot left on the plate might be more easily found by examining the specular reflection. The glass plates used in the experiments were uniformly ground.

Judging from these results it appears entirely possible, after calibration of the instrument by either the specular or diffuse measurements or perhaps a combination of both, to determine roughness or depth of graining; and also, by moving the instrument about on the plate, to determine the degree of uniformity of the graining.

85 PRIZE DISCUSSION
By HAROLD T. OESON
MINNEAPOLIS, MINN.

The accompanying sketch contains the germ of an idea which might possibly be developed to provide a direct reading instrument which would indicate the suitability of a grained metal surface for lithography. Considerable experimental work would be necessary, however, before perfecting the device.

A Weston type photocell has an axially drilled hole, through which a standard quantity of light is allowed to fall on the sample to be tested which is placed at a fixed distance from the face of the cell.



Due to the grained surface the incident light will be scattered in all directions. Certain of this scattered light will fall on the photocell whose output, which varies with the amount of light received, operates a sensitive galvanometer. Once the instrument is calibrated, the suitability of a sample can be readily determined by the deflection of the galvanometer.

By obtaining the deflection from a large number of samples the suitability of which would subsequently have to be determined quantitatively by the ink spot test, and plotting the area of ink spot against the deflection of the galvanometer, we would obtain the desired calibration curve.

In operation it would be necessary to insure the constancy of the illumination supplied by the light source, otherwise it would be impossible to insure consistent results. One way of doing this would be to provide an invariable, polished surface with each instrument. Then, when it is desired to take readings, this surface could be inserted in place of the sample and the light source current adjusted until the galvanometer deflection conforms to that obtained from the sample when the instrument was calibrated.

Readily adaptable instruments are commercially available from American Instrument Co., General Electric, Pfaltz & Bauer, Westinghouse, etc. If one examined the *Instruments* annual indexes for the 1935, 1936, and 1937 volumes, searching under such titles as "reflectometer" or "glossmeter," or under manufacturers' names, he would undoubtedly find a suitable instrument.

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NOTE ON THROTTLING ELECTRIC HEAT

Continued from page 305

ny of the other means listed. It is apparent also that ne initial cost of its accessory equipment is the least and, most cases, the total power consumption is the least. he cost of maintenance depends upon the accuracy re uired and will be discussed later.

Practically all industrial furnaces and ovens are con rolled (if at all) with on-and-off or two-position con rollers. In many cases the results are satisfactory and, in fact, heretofore no improvement would have followed a change to older types of throttling controllers. Today the question can be raised again in many instances, whether it is advisable to change from on-and-off or two position control, to throttling.

The principal disadvantages of on-and-off control are: (1) The amplitude of temperature oscillations is greater than with any other mode (except the seldom-used floating control); (2) The heating element is subjected to maximum temperature and stress; (3) The unavoidable dead-zone impresses a magnified additional amplitude to the sustained oscillations; (4) No adjustments are available for counteracting the effects of process lag; (5) Serious over-shooting often terminates the heating-up period of batch processes.

The principal disadvantages of two-position control are:

(1) Any improvement over on-and-off control is obtained at the expense of ability to correct for an unexpected change in load; (2) At least two voltages or two-heater units are required, or a power-consuming rheostat is required; (3) Reasonably rapid heating up is attained only by using a third hand-selected "position" (voltage or rheostatic).

The disadvantages of on-and-off and of two position control have been briefly referred to, in order to contrast them with the advantages of throttling, particularly by the Gouy method. These are:

(1) Accuracy of control ("regulation") can always be improved over the on-and-off or two-position modes; (2) No sacrifice is necessary to retain ability to correct for any change in load; (3) No serious over-shooting terminates a heating up period; (4) Adjustment for process lag is available; (5) Life of furnace resistors is increased, and in some cases, the life of other parts; (6) Successful control of furnace atmosphere is promoted.

Exact figures, showing whether or not the higher cost of maintaining a contactor for throttling by the Gouy method is warranted, cannot be set down on theoretical grounds. Neither are data available now, based on experience. While in many cases improved control is highly desirable at any reasonable expense, in some cases the degree of improvement in product or decrease in rejections will balance the increased maintenance charge. Only where the output is relatively small will the slight increase in this charge be worth consideration. On the other hand maintenance charges are not significant in the case of small units requiring a few kilowatts.

We may conclude then that from the viewpoint of accuracy and economy the Gouy principle can be preferred to other means of throttling control, and further that the choice between throttling and on-and-off or two-position control may depend upon the relative values of increased accuracy offset, possibly, by an increased maintenance charge.

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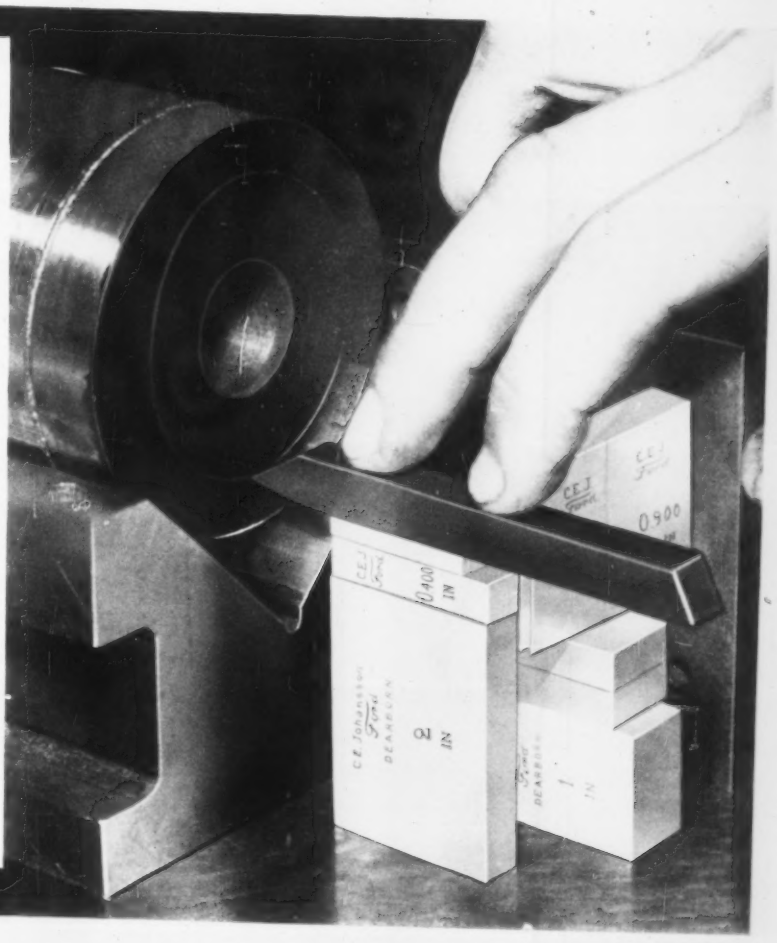

MODERN SCRATCH HARDNESS METHODS

Continued from page 312

Fig. 76 shows the artist's conception of the cross sectional view of the microcut made by Bierbaum's standard instrument. If what is actually measured in this microcut is not exactly what is desired, then if the diamond edge is perfect one could imagine that the depth of the cut might be a more accurate gage of hardness than is the width of the cut. This point might be studied in much

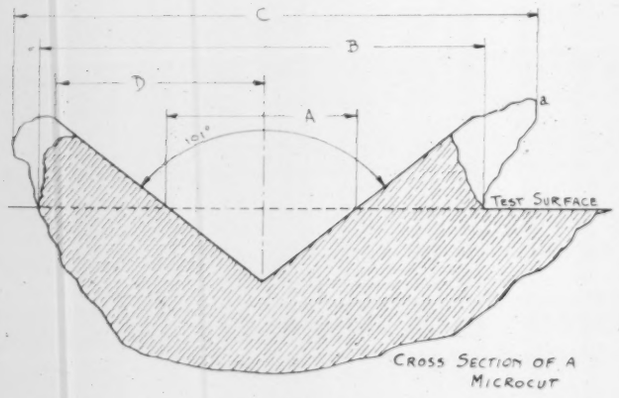

Fig. 76. An artist's view of the cross-section of the microcut of the Microcharacter.

The values: A—what one would like to get and cannot.
B—what one has to be contented with.
C—what the casual observer sees.
D—what extremely oblique illumination gives in extremely contrasty photomicrography.

the same way as Foss and Brumfield[7] studied the shape of the Brinell ball indentation in which they came to the conclusion that diameter measurements were more satisfactory for the indentation method than were the depth measurements.

USE OF SCRATCH METHOD ON COLD-WORKED SURFACES

In discussing Graton's scleroneter it was pointed out that there seemed to be some doubt about the suitability of the scratch method for measuring the hardness of cold worked surfaces. Some additional observations have come to hand since the foregoing material was submitted. At a recent symposium on metals the author heard a metallurgist make the statement (which appeared to be a general statement) that hardness produced by cold working could not be measured by a scratch method. No reason was given for this statement, but, if so, it is important to know why. As will be shown later, magnetic methods do not seem adaptable to the measurement of hardness in cold worked materials. O'Neill[8] in his excellent book quotes Rawdon as saying that the microcharacter is not suitable for studying the effects of cold working of metal, and this seems to fit in with the statement of the metallurgist just given.

To the statement of this point of view in a letter to the inventor of the microcharacter, the following reply was received: "If one slightly etches the surface of the cold worked metal he is testing to bring out the grains, he will observe an interesting phenomenon by finding a hardening effect in the area of slippage planes and no effect in the grains or parts of grains in which no slippage occurred." From the date of publication it appears probable that Rawdon used the microcharacter in the days when sapphires were ground for the cutting edge instead of diamonds. The results obtained with sapphires were not reliable as a rule. Any blunting of the cutting edge gives wholly fallacious results and the diamond appears to be the only substance which will stand up to the continued work of testing.

[7] F. E. Foss and R. C. Brumfield, Some Measurements of the Shape of Brinell Ball Indentation. *Proceedings American Society for Testing Materials*, Vol. 22, Part II, 1922, pages 1-24.

[8] H. O'Neill, The Hardness of Metals and Its Measurement. See page 146, pages 1-292. Chapman and Hall, London, 1934.

PRODUCTION-LINE TESTS OF MOTOR WINDINGS AND MOTORS

Continued from page 307

Slip measurements are made by means of a stroboscopic slip-meter.

(c) Locked-rotor tests are made with the same set-up used in determining performance, except that the armature of the dynamometer is mechanically locked to the frame so that both members tend to rotate as a unit.

(b) No-load tests are made with a metering table in conjunction with an induction regulator.

NOISE TESTS

Motors desired for quiet operation are tested under ideal conditions in a 12′ × 12′ sound-insulated room (Fig. 5) adjacent to the assembly conveyor. The ceiling and walls are covered with efficient sound-absorbing material. The motor being tested is loaded by a d-c. generator located outside this room and coupled to the motor by a jack shaft projecting through the wall. The couplings on the jack shaft are insulated to kill the transmission of generator noise to the motor. In addition to a sound level meter indicating noise directly in decibels, a metering table is installed in the room; on it are located instruments and the control for loading the generator; and also the control for an induction regulator which permits variable voltage to be applied to the motor—which is highly desirable in determing the effects of voltage changes on magnetic noise.

APPENDIX A

POWER FACILITIES FOR ENGINEERING TESTS

60-cycle power is furnished by two 300-kva. transformer banks. The incoming feed to these banks is 2200 volts, 3 phase. The primaries are connected in delta and the secondaries are connected in star. Taps are taken off the secondaries to give all standard voltages. These taps are taken to a main distribution board.

The transformers are designed with low reactance to give good regulation. A 3-phase regulator with 10% regulation is connected to the primary of each bank to take care of line fluctuation.

The 25-cycle power is furnished by a 150-kva. transformer bank, connected similarly to the 60-cycle bank and fed with 2200 volts.

The odd frequency power is obtained from two motor generator sets; 200 kva. and 20 kva. The driving motors have a speed range of 20 to 68 cycles. The generators have low synchronous reactance to give good regulation in making locked-rotor tests. The design of the generators was given particular attention so as to have the wave form free from harmonics.

The 50-kw., 250-volt d-c. generators are coupled to an induction motor for supplying d-c. power for driving dynamometers when taking recuperation tests and speed-torque curves at negative speeds. The controls on these generators are arranged so that they may be connected to either of the variable-frequency sets to recirculate power in conducting pump-back tests on two duplicate motors. The generators can be used independently in parallel or in series.

Two 10-kw. d-c. generators with flat regulation; one 125 volts and the other 250 volts, furnish excitation for all generators and dynamometers.

To obtain odd voltages and for special test setups there are eight 37.5-kva. auto-transformers with taps to give 5-volt steps from 0 to 480 volts. These transformers can be connected star, delta for 3-phase, or they may be Scott connected to change from 3-phase to 2-phase.

There are four 3-phase induction regulators with 25% regulation for maintaining constant voltage when conducting performance tests, and for variable voltage in taking saturation curves.

All transformers, regulators, motor-generator sets and line breakers are located on the second floor directly above the distribution board. All conduits are run vertically from back of the distribution board to the apparatus on the floor above, making a neat installation. The oil-filled apparatus is installed on the second floor to isolate it and thus reduce the fire hazard, and to permit a better arrangement of equipment on the testing floor.

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Taylor Instrument Cos.
Humidity & Temperature
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
H-B Instrument Co.
Johnson Service Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Humidity—Time
Friez & Sons, Inc.
C. J. Tagliabue Mfg. Co.
Lighting
General Electric Co.
G-M Labs., Inc.
Pfaltz & Bauer, Inc.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.
Liquid Level
American Meter Co.
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.

out in the field

THE MAINTAINED in-built accuracy of Westcott orifice meters, whether for Indicating, Recording or Integrating, is embodied in: precision machining of differential gage body chambers . . . low angle of float travel . . . small angular travel of static pressure tube . . . only one movable part between mercury surface and chart record. ● Information is available on request.

AMERICAN METER COMPANY
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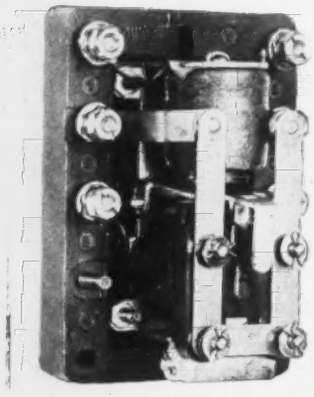
Chace Thermostatic Bimetal is the active element employed in the new Square D double-break circuit breaker, which automatically breaks the circuit should an "overload" or "short" occur. Where temperature is a factor and positive, unfailing automatic movement is required, use Chace Thermostatic Bimetal. Offered in various types, each to meet specific demands.

W. M. CHACE CO.
1609 Beard Avenue - - - Detroit Mich.



WRITE FOR CATALOG

STRUTHERS DUNN, Inc.

125 N. Juniper St. Philadelphia, Pa.

Manufacturing Specialists of

ELECTRICAL CONTROL EQUIPMENT

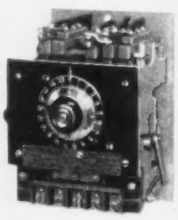
RELAYS

A TYPE FOR EVERY NEED

MECHANICAL LATCH-IN ELECTRICAL RESET • MERCURY CONTACT • MIDGET • SENSITIVE • POLARIZED • TIMING • OVERLOAD • INSTRUMENT CONTROLLED • LAMP CONTROL • CLOSE DIFFERENTIAL • TELEPHONE AUXILIARY • POWER OFF • RATCHET TYPE SEQUENCE

Exactly

1 MINUTE 49 SECONDS



Cat. No. HX10
Timing Range
2 Sec. to 20 Min.

Pat's. Issued & Pend.

Such specifications are common in modern manufacturing processes. Engineers know that exact time intervals result in uniformity of products and often in large savings of time and money.

The MICROFLEX* Instantaneous Reset Timer is noted for its exceptional accuracy. In one type, the HX11, an accuracy of 0.1 second is guaranteed over the entire timing range from 0.2 seconds to 2 minutes. In the HX10 type, accuracy is guaranteed within one second over the entire timing range. Other types are equally exact. And in addition, exact time settings are made easily and conveniently on the Vernier-Micrometer dial.

Write for Bulletin 255 today

*Trade Mark Registered

EAGLE SIGNAL CORP.

MOLINE ILLINOIS

Friez & Sons, Inc.
General Electric Co.
G-M Labs., Inc.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Powers Regulator Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Moisture-content
Askania Regulator Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.

Pressure & Vacuum
American Meter Co.
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Continental Elec. Co.
Foxboro Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Pyrometer
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Illinois Testing Labs.
Leeds & Northrup Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Rate-Volume
American Meter Co.
Askania Regulator Co.
Cochrane Corp.
Foxboro Co.
Mason-Neilan Reg. Co.
C. J. Tagliabue Mfg. Co.

Refrigeration
Bristol Co.
Brown Instrument Co.
Burling Inst. Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Specific Gravity
Askania Regulator Co.
Bailey Meter Co.
Foxboro Co.
Pfaltz & Bauer, Inc.
C. J. Tagliabue Mfg. Co.

Tachometer
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.

Temperature
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Burling Inst. Co.
Cochrane Corp.
Charles Engelhard, Inc.
Foxboro Co.
Friez & Sons, Inc.
G-M Labs., Inc.
Illinois Testing Labs.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Temperature-Time
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Time
Bristol Co.
Brown Instrument Co.
Eagle Signal Corp.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
Johnson Service Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Ward Leonard Elec. Co.

Vacuum
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Continental Elec. Co.
Foxboro Co.
H-B Instrument Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Valve—Motor-Operated
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Voltage A. C.
Ward Leonard Elec. Co.
Wheelco Instr. Co.

COUNTERS—Magnetic
Ward Leonard Elec. Co.

Revolution
Bristol Co.
Brown Instrument Co.
Gaertner Scientific Corp.

Stroke
Bristol Co.
Eagle Signal Corp.

CUBIC FOOT BOTTLES
American Meter Co.

CURRENT RECORDERS
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.

CYCLE CONTROLLERS
Bristol Co.
Brown Instrument Co.
Foxboro Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

CYCLE COUNTERS
General Radio Co.
Westinghouse E. & M. Co.

CYCLE RECORDERS
General Electric Co.

CYLINDER GAGES
Federal Products Corp.

DEMAND METERS
Gas
Foxboro Co.
Electric
General Electric Co.
Westinghouse E. & M. Co.

DEPTH GAGES
Federal Products Corp.

DIAL INDICATORS
Federal Products Corp.

DIVIDING MACHINES
Gaertner Scientific Corp.

DRAFT GAGES—See Gages

DYNAMOMETERS
General Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

EARTH CURRENT METERS
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.

EBULLIOMETERS
C. J. Tagliabue Mfg. Co.

ELECTRIC TELEMETERS —See Remote Metering Equipment

ELECTRODES for pH
G-M Labs., Inc.
Hellige, Inc.
Leeds & Northrup Co.
Pfaltz & Bauer, Inc.

ELECTRONIC METERS
General Electric Co.
General Radio Co.
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.

EXTENSOMETERS
Riehle Div. Am. Mach.

FAULT FINDERS
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Westinghouse E. & M. Co.

FLASH & BURNING POINT TESTERS
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

FLOW METERS
Indicating
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Mason-Neilan Reg. Co.
Pfaltz & Bauer, Inc.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Indicating & Recording
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Mason-Neilan Reg. Co.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Integrating & Recording
American Meter Co.
Bailey Meter Co.
Bristol Co.
Cochrane Corp.
Brown Instrument Co.
Foxboro Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

FLUE GAS ANALYZERS
Brown Instrument Co.
Charles Engelhard, Inc.
Foxboro Co.
Leeds & Northrup Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.

FLUXMETERS
Kurman Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Rubicon Co.

FOOT CANDLE METERS
General Electric Co.
G-M Labs., Inc.
Pfaltz & Bauer, Inc.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.

FREQUENCY METERS
Indicating
James G. Biddle Co.
Bristol Co.
General Electric Co.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.
Recording
Bristol Co.
General Electric Co.
Leeds & Northrup Co.
Westinghouse E. & M. Co.
Standards
General Radio Co.
Leeds & Northrup Co.

FRITTED GLASS
Fish Schurman Corp.

FURNACE ATMOSPHERE RECORDERS
Brown Instrument Co.

FURNACE CONTROLS
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Burling Inst. Co.
Foxboro Co.
Friez & Sons, Inc.
Illinois Testing Labs.
Leeds & Northrup Co.
Minn.-Honeywell Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

GAGES
Absolute Pressure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Continental Elec. Co.
Foxboro Co.
Friez & Sons, Inc.
Mason-Neilan Reg. Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Caliper
Federal Products Corp.
Cylinder
Federal Products Corp.
Depth
Federal Products Corp.
Dial Indicator
Federal Products Corp.
Differential Pressure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Draft
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Republic Flow Meters Co.
Drill
Bausch & Lomb Opt. Co.
Electric
General Electric Co.
Flow
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Grinding
Federal Products Corp.
Liquid Level
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Paper Thickness—Continuous
Federal Products Corp.
Precision Measuring
Federal Products Corp.

ssure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

essure-Temperature
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Cochrane Corp.
Foxboro Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

essure & Vacuum
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos

Rain
Friez & Sons, Inc.
Taylor Instrument Cos

Recording—Distance
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co
Mason-Neilan Reg. Co.
Pioneer Instrument Co
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Strain
General Electric Co.

Vacuum
Continental Elec. Co.
Bristol Co.
Brown Instrument Co
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
H-B Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos

Volume
American Meter Co.
Brown Instrument Co
Foxboro Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.

Wind
Bristol Co.
Brown Instrument Co.
Friez & Sons, Inc.
Taylor Instrument Cos

Wire
Federal Products Corp.

GAGE BLOCKS
Ford Motor Co.

GALVANOMETERS
American Meter Co.
James G. Biddle Co.
Brown Instrument Co.
General Electric Co.
G-M Labs., Inc.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Pfaltz & Bauer, Inc.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Rubicon Corp.
Taylor Instrument Cos.
Triplett Elec. Inst. Co.
Westinghouse E & M Co
Weston Elec. Inst. Corp
Wheelco Instr. Co.

Mirror
Fish-Schurman Corp
G-M Labs., Inc.
Leeds & Northrup Co.
Pfaltz & Bauer, Inc.
Rubicon Corp.

Vacuum-tube
Heilige, Inc.
Leeds & Northrup Co.

GAS ANALYTICAL METERS

Chemical
Rubicon Co.
C. J. Tagliabue Mfg. Co.

Electrical
Brown Instrument Co
Charles Engelhard, Inc.
Leeds & Northrup Co.

GAS FLOW INDICATORS
American Meter Co.
Bailey Meter Co.
Foxboro Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.

GAS LEAK INDICATORS
Pioneer Instrument Co.
Taylor Instrument Cos

GAS-METERS
American Meter Co.
Bailey Meter Co.
Brown Instrument Co
Foxboro Co.
Republic Flow Meters Co.

Dry Test
American Meter Co.
Foxboro Co.

Wet Test
American Meter Co.
Foxboro Co.

GLASS STRAIN TESTERS
Gaertner Scientific Corp
Pfaltz & Bauer, Inc.

GOVERNORS

Pressure
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos

Pump
Bailey Meter Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos

GRADUATING MACHINES
Gaertner Scientific Corp.

GRAVITOMETERS
American Meter Co.

GROUND TESTERS
James G. Biddle Co.
Roller-Smith Co.
Weston Elec. Inst. Corp

HARDNESS TESTERS
Riehle Div. Am. Mach.

HELIOMETERS
Gaertner Scientific Corp.

HELIOSTATS
Gaertner Scientific Corp.

HIGH FREQUENCY APPARATUS
General Radio Co.
Hickok Elec. Inst. Co.
Rawson Elec. Inst. Co
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E & M Co
Weston Elec. Inst. Corp

HIGH VOLTAGE

Indicators
Hickok Elec. Inst. Co.
Roller-Smith Co.
Shallcross Mfg. Co.
Triplett Elec. Inst. Co.
Westinghouse E & M Co
Weston Elec. Inst. Corp

Measuring Devices
Bristol Co.
General Electric Co.
Hickok Elec. Inst. Co.
Int. Resistance Co.
Roller-Smith Co.
Shallcross Mfg. Co.
Triplett Elec. Inst. Co.
Westinghouse E & M Co
Weston Elec. Inst. Corp

Testing Devices
General Electric Co.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Triplett Elec. Inst. Co.
Westinghouse E. & M. Co.

HOUR COUNTERS
General Electric Co.
Westinghouse E. & M. Co.
Weston Elec. Inst. Corp.

HUMIDITY CONTROLS —See Controls

HUMIDITY RECORDERS

Wet & Dry Bulb
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
H-B Instrument Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

HYDROGEN-ION INDICATORS
Heilige, Inc.
Leeds & Northrup Co.
Lewis Engineering Co.
Pfaltz & Bauer, Inc.
Rubicon Corp.

HYDROMETERS
H-B Instrument Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

HYGROMETERS
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
H-B Instrument Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

ILLUMINOMETERS
General Electric Co.
G-M Labs., Inc.
Leeds & Northrup Co.
Pfaltz & Bauer, Inc.
Westinghouse E & M Co.
Weston Elec. Inst. Corp

INDICATORS—See Gages

INDUCTANCES
General Radio Co.
Leeds & Northrup Co.
Rubicon Co.

INSULATION TESTING EQUIPMENT
James G. Biddle Co.
General Electric Co.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Rubicon Co.
Shallcross Mfg. Co.
Westinghouse E & M Co.

INTERFEROMETERS
Gaertner Scientific Corp.

INTERNAL SMALL HOLE GAGE
Federal Products Corp.

KEYS AND SWITCHES
Brown Instrument Co.
General Radio Co.
Leeds & Northrup Co.
Rubicon Co.
C. J. Tagliabue Mfg. Co.
Triplett Elec. Inst. Co.

LABORATORY APPARATUS
Fish-Schurman Corp.
Gaertner Scientific Corp.
G-M Labs., Inc.
H-B Instrument Co.
Heilige, Inc.
Leeds & Northrup Co.
Pfaltz & Bauer, Inc.
C. J. Tagliabue Mfg. Co.

LACTOMETERS
Taylor Instrument Cos.

LEAD TESTING GAGES
Federal Products Corp.
C. J. Tagliabue Mfg. Co.

LENSES
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.
E. Leitz, Inc.

LEVELS
Engineer's, Wye, Precision, Prism
Pfaltz & Bauer, Inc.
Taylor Instrument Cos.

LIGHT FILTERS
Fish-Schurman Co.

LIGHT SOURCES
James G. Biddle Co.
Fish-Schurman Corp.
Gaertner Scientific Corp.
General Electric Co.
G-M Labs., Inc.
Pfaltz & Bauer, Inc.
Westinghouse E & M. Co.
Weston Elec. Inst. Corp

LIQUID LEVEL RECORDERS
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co
Cochrane Corp.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Westinghouse E & M. Co.

MAGNETIC INSPECTORS
Leeds & Northrup Co.
Rubicon Co.

MAGNETIC RELAYS
Continental Electric Co.
Friez & Sons, Inc.
G-M Labs., Inc.
H-B Instrument Co.
Roller-Smith Co.
Ward Leonard Elec. Co.
Weston Elec. Inst. Corp

MAGNETOMETERS
Roller-Smith Co.
Rubicon Co.

MAGNIFIERS
Burrette, Scale, etc.
Gaertner Scientific Corp.

MANOMETERS
American Meter Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
H-B Instrument Co.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.

MASTER CLOCKS
Gaertner Scientific Corp.
General Electric Co.

MEGOHMMETERS
James G. Biddle Co.
General Radio Co.
Hickok Elec. Inst. Co.
Illinois Testing Labs.
Roller-Smith Co.
Shallcross Mfg. Co.
Westinghouse E & M. Co.
Weston Elec. Inst. Corp.

MEGOHM VOLTMETERS
Hickok Elec. Inst. Co.
Roller-Smith Co.
Shallcross Mfg. Co.
Triplett Elec. Inst. Co.
Westinghouse E & M. Co.
Weston Elec. Inst. Corp.

MICROAMMETERS
General Electric Co.
Hickok Elec. Inst. Co.
Pfaltz & Bauer, Inc.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E & M. Co.
Weston Elec. Inst. Corp.

MICRODENSITOMETERS
Gaertner Scientific Corp.

MICROFARADMETERS
James G. Biddle Co.
General Radio Co.
Hickok Elec. Inst. Co.
Leeds & Northrup Co.
Roller-Smith Co.
Shallcross Mfg. Co.
Weston Elec. Inst. Corp.

MICROMETERS
Gaertner Scientific Corp.

MICROPHOTOMETERS
Gaertner Scientific Corp.

MICROSCOPES

Biological
Bausch & Lomb Opt. Co.
E. Leitz, Inc.
Pfaltz & Bauer, Inc.

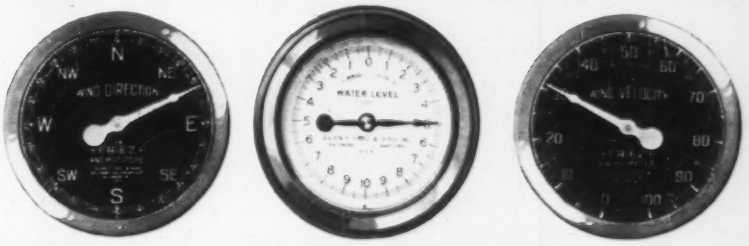
Brinell
Gaertner Scientific Corp.

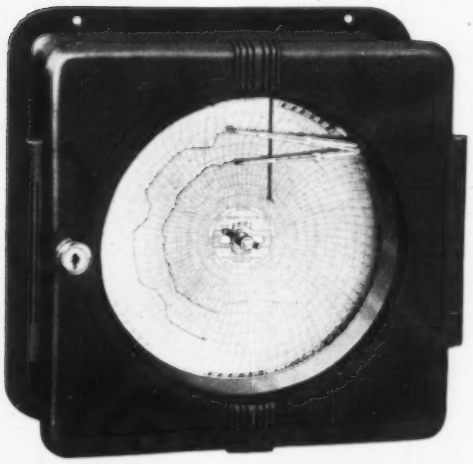
Inspection
Gaertner Scientific Corp.
Pfaltz & Bauer, Inc.

Measuring
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.
E. Leitz, Inc.

Metallographic
Bausch & Lomb Opt. Co.
E. Leitz, Inc.
Pfaltz & Bauer, Inc.

WIND WATER WEATHER





REPORTED FROM AFAR

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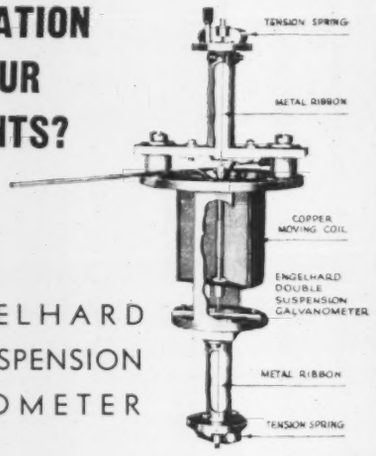

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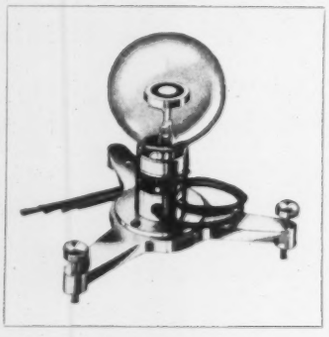

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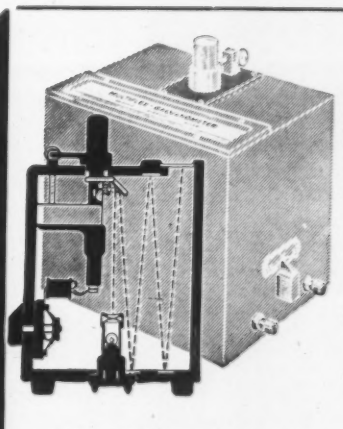

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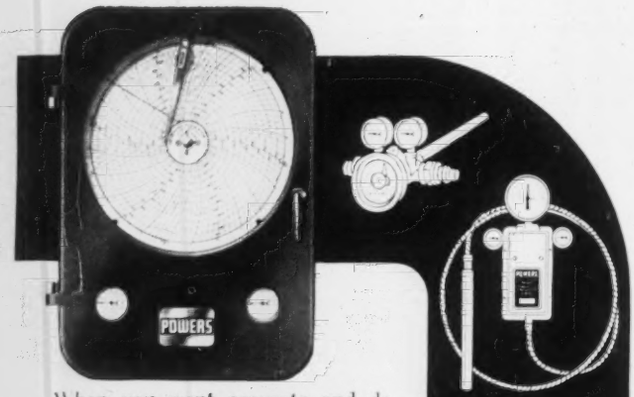

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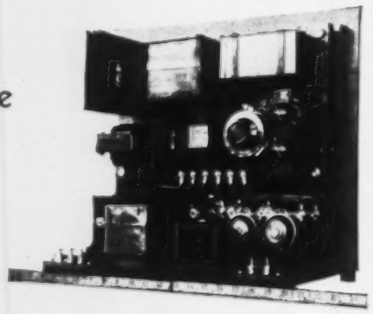

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Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

THERMOSTATIC BELLOWS
Clifford Mfg. Co.

THERMOSTATIC BIMETAL
W. M. Chace Co.
General Plate Co.

THICKNESS GAGES
Federal Products Corp.

TIME METERS
Friez & Sons, Inc.
General Electric Co.
Leeds & Northrup Co.
Westinghouse E & M Co.
Weston Elec. Inst. Corp.

TIME OPERATION RECORDERS
Bristol Company
Foxboro Co.
Friez & Sons, Inc.
C. J. Tagliabue Mfg. Co.

TIME RECORDERS
Bristol Company
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.

TIME SWITCHES
General Electric Co.
Westinghouse E & M Co.

TIMERS
Eagle Signal Corp.
General Electric Co.
Leeds & Northrup Co.
Rawson Elec. Inst. Co.
Rubicon Co.
C. J. Tagliabue Mfg. Co.

TORSIOGRAPHS

TOTALIZING INSTRUMENTS
American Meter Co.
Bailey Meter Co.
General Electric Co.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Westinghouse E & M Co.

TOTALIZING RELAYS
Electric
General Electric Co.
Leeds & Northrup Co.

TRAM POINTS
Ford Motor Co.

TRANSFORMATION POINT RECORDERS
Brown Instrument Co.
Leeds & Northrup Co.
C. J. Tagliabue Mfg. Co.

TRANSFORMERS (Instrument)
Friez & Sons, Inc.
General Electric Co.
General Radio Co.
Hickok Elec. Inst. Co.
Roller-Smith Co.
Rubicon Co.
Triplett Elec. Inst. Co.
Westinghouse E & M Co.
Weston Elec. Inst. Corp.

Split Core
Roller-Smith Co.
Westinghouse E & M Co.

Variable Voltage
General Radio Co.

TRANSITS
Astronomical
Gaertner Scientific Corp.
Pocket
Taylor Instrument Cos.

TRANSMITTANCY INDICATORS
Pfaltz & Bauer, Inc.
Westinghouse E & M Co.

TUBES, CATHODE-RAY
Allen B. DuMont Labs.

TUNING FORKS—Electrically Driven
Gaertner Scientific Corp.
General Electric Co.
General Radio Co.
Leeds & Northrup Co.
Rubicon Co.

TURBIDIMETERS
Bausch & Lomb Opt. Co.
Gaertner Scientific Corp.
Heilige, Inc.
Pfaltz & Bauer, Inc.

U-TUBE MANOMETERS
American Meter Co.
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
H-B Instrument Co.
Pioneer Instrument Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

VACUUM RECORDERS
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Continental Elec. Co.
Foxboro Co.
Leeds & Northrup Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

VACUUM TUBE BRIDGES
General Radio Company
Leeds & Northrup Co.

VACUUM TUBE VOLTMETERS
General Electric Co.
General Radio Co.
Hickok Elec. Inst. Co.
Rawson Elec. Inst. Co.
Weston Elec. Inst. Corp.

VALVE POSITIONERS
Askania Regulator Co.
Foxboro Co.

VALVES
Automatic Shut-Off
Askania Regulator Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
H-B Instrument Co.
Johnson Service Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Back Pressure
American Meter Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.

Balanced
Bailey Meter Co.
Brown Instrument Co.
Foxboro Co.
Johnson Service Co.
Mason-Neilan Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Blow-Off
American Meter Co.

Diaphragm
Bailey Meter Co.
Bristol Company
Brown Instrument Co.
Foxboro Co.
Johnson Service Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.

Differential
American Meter Co.
Mason-Neilan Reg. Co.

Electrically Operated
Bristol Company
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
General Electric Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Mixing
Powers Regulator Co.

Motor Operated
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Bristol Company
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
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Proportional Air-Gas
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Askania Regulator Co.
Brown Instrument Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Wheelco Instr. Co.

Reducing
Askania Regulator Co.
Bailey Meter Co.
Brown Instrument Co.
Mason-Neilan Reg. Co.
Powers Regulator Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
Wheelco Instr. Co.

Regulating
American Meter Co.
Askania Regulator Co.
Bailey Meter Co.
Bristol Co.
Brown Instrument Co.
Foxboro Co.
Friez & Sons, Inc.
Johnson Service Co.
Leeds & Northrup Co.
Mason-Neilan Reg. Co.
Minn.-Honeywell Reg. Co.
Powers Regulator Co.
Republic Flow Meters Co.
C. J. Tagliabue Mfg. Co.
Taylor Instrument Cos.
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VENTURI METERS
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Brown Instrument Co.
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VIBRATING-REED INSTRUMENTS
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VIBROGRAPHS

VISCOSIMETERS
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Int. Resistance Co.
Rubicon Co.
Shallcross Mfg. Co.
Ward Leonard Elec. Co.

VOLT-AMMETERS
General Electric Co.
Hickok Elec. Inst. Co.
Roller-Smith Co.
Westinghouse E & M Co.
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VOLTMETERS
Electrostatic
General Electric Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E & M Co.

Indicating
General Electric Co.
General Radio Co.
Hickok Elec. Inst. Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Triplett Elec. Inst. Co.
Westinghouse E & M Co.
Weston Elec. Inst. Corp.

Recording
Bristol Company
General Electric Co.
Leeds & Northrup Co.
Roller-Smith Co.
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Thermionic Rectifier
General Radio Co.

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Brown Instrument Co.
Foxboro Co.
Mason-Neilan Reg. Co.
Republic Flow Meters Co.
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General Electric Co.
Hickok Elec. Inst. Co.
Rawson Elec. Inst. Co.
Roller-Smith Co.
Westinghouse E & M Co.
Weston Elec. Inst. Corp.
Recording
Bristol Company
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Roller-Smith Co.
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MANUFACTURERS' NEW LITERATURE

In this department we report ALL pieces of NEW literature pertaining to Instrumentation, received from the manufacturers. Readers may secure without cost (unless noted) any or all items reported here, by filling out and mailing the prepaid post-card.

E388 Clinical Instruments. 56-page 6" × 9" General Catalog describes complete line of clinical thermometers, hypodermic syringes and needles, etc. Eisele & Co., 400 First Ave., N., Nashville, Tenn.

E389 Temperature Equipment. 6-page envelope size Bulletin No. 102A is a highly condensed catalog of industrial instruments. It includes also hydrometers, etc. H. O. Trerice Co., 1420 W. Lafayette Blvd., Detroit, Mich.

E390 Bin Level Indicator. 8-page envelope size leaflet describes the "Bin-Dicator" for signalling and controlling the level of bulk materials in bins. The Bin-Dicator Co., Detroit, Mich.

E391 Solenoid Valve. 4-page 8½" × 11" Bulletin 401 describes new Model 73-RB; 4-page 8½" × 11" Bulletin 405 describes Model 71-B for water service. Automatic Products Co., Milwaukee, Wis.

E392 High-pressure Valves. 4-page 8½" × 11" bulletin illustrates and describes new Hancock Duravalve with integral Stellite seat for high-pressure high-temperature service. Hancock Valve Div., Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

E393 Resistance and Insulation Measurements. 4-page 7¾" × 10¾" Bulletin 35 describes improved ohm scales for "Meg" and "Super Meg" insulation testers. 8-page 7¾" × 10¾" Bulletin 1540 describes several types of "Megger" direct-reading ohmmeters. 4-page 7¾" × 10¾" Bulletin 1545 describes midget megger testers. James G. Biddle Co., 1211-13 Arch St., Philadelphia, Pa.

E394 Electric Flow Meters. 4-page 8½" × 11" Bulletin 494 illustrates applications and outlines the special features of Bristol's New Electric Flow Meter. The Bristol Company, Waterbury, Conn.

E395 "The Oscillographer." The August-Sept. issue of this 8-page 6" × 9" house-organ features articles on television in Europe and on oscillograph amplifier design. Allen B. Du Mont Laboratories, Inc., 532 Valley Rd., Upper Montclair, N. Y.

E396 Room Temperature Control. 20-page 9¼" × 6¼" booklet entitled "And then . . . we turn on the heat," describes "Heat Accelerating" thermostat, is written for the layman. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

E397 Combustion Safeguard. 8-page 8½" × 11" Bulletin No. 1101 describes the "Flame-Otrol" gas burner safety device, illustrates typical installations, covers also solenoid valves. Wheelco Instruments Co., 1933 S. Halstead St., Chicago, Ill.

E398 Dry Chemical Feeder. 4-page 8½" × 11" Form 2070 describes dry-material feeder with provision for automatic proportional feed with quantity or rate fluid meters. The Permutit Company, 330 W. 42 St., New York, N. Y.

E399 Polariscope. 4-page 4¼" × 8" leaflet describes the Marks Polarized Colomat, which includes light source and analyzer for rapid inspection of products. Polarized Products Corp., Whitestone, L. I., N. Y.

E400 Sound Devices. More than 100 commercial sound products, including P-A and sound-re-inforcement equipment, inter-office communications systems, amplifiers, speakers, microphones, etc. are described in new 36-page catalog. Commercial Sound Section, RCA Manufacturing Co., Camden, N. J.

E401 Radio Service Manual. 200-page pocket-size book covers volume controls, resistor-tube replacements, circuit diagrams, servicing hints, ballast data, attenuator data, etc. Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.

E402 "Flocontrol" Valves. 8-page 8½" × 11" Bulletin 7500-G is devoted entirely to this type of valve which has an indicating scale. Hancock Valve Division, Manning, Maxwell & Moore, Inc., Bridgeport, Conn.

E403 Amplifiers. Four new mimeographed 8½" × 11" sheets for insertion in binder, covering new types of sound-system amplifiers. Commercial Sound Section, RCA Mfg. Co., Inc., Camden, N. J.

E404 Combustion Safeguard. 4-page 8½" × 11" Form 205, superseding Form 95-842, describes new type of "Protectorelay" safety control for industrial oil burners. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

E405 Spectrograph. 4-page 6¼" × 9½" bulletin describes grating spectograph for industrial laboratories and universities. Baird Associates, 20 Palmer St., Cambridge, Mass.

E406 Diffraction Tube. 4-page 6¼" × 9½" bulletin describes completely-demountable cold-cathode X-ray diffraction tube with interchangeable targets. Baird Associates, 20 Palmer St., Cambridge, Mass.

E407 Solenoid Valves. 2-page 8½" × 11" Leaflet 3873 describes four types of solenoid valves for various fluids and various applications. Supreme Electric Products Corp., Rochester, N. Y.

E408 Torsion Dynamometer. 4-page 8½" × 11¾" bulletin illustrates and briefly describes the torsion dynamometers of Alfred J. Amsler & Co., Schaffhouse, Switzerland. Herman A. Holz, 167 E. 33 Street, New York, N. Y.

E409 Rheostats and Resistance Units. 12-page 8½" × 11" Catalog No. 16 covers vitreous enameled, cement-coated, center-tapped, and other types of resistors, switches, attenuators, etc. Ohmite Mfg. Co., 4835 W. Flournoy St., Chicago, Ill.

E410 "Thwing's Foundry Visitor." Volume 3 No. 2 of this 2-page 8" × 10½" house-organ is devoted to bearing bronze, high lead alloys, and cast-to-size bearings. Thwing-Albert Instrument Co., 3339 Lancaster Ave., Philadelphia, Pa.

E411 Tube Couplings. Twelve 8½" × 11" data sheets in binder, presenting complete description and elaborate tabulated data on Packless self-flaring tube couplings for quick assembly right at the job. Applicable not only to copper tubing but for other materials. Packless Metal Products Corp., 37-14 29th St., Long Island City, N. Y.

E412 Industrial Thermometers. 24-page 8½" × 11" Catalog No. 1125B starts with four pages of engineering descriptions, gives details of TAG line of industrial, miscellaneous metal and woodback thermometers, also

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INSTRUMENTS (December, 1937)
Pittsburgh

Please have the following catalogues, etc., reviewed in this issue sent to me.
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hygrometers, U gages, mercurial vacuum gages and mercurial barometers. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

E413 Heating, Ventilating & Air Conditioning Instruments. 48 - page $8\frac{1}{2}$" × 11" condensed catalog and price list covers all Minneapolis-Honeywell controls and control systems including new National pneumatic controls, also Brown indicating, recording and controlling instruments. Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.

E414 Pyrometers. 8-page $8\frac{1}{2}$"×11" Bulletin No. 503 describes indicating pyrometers in edgewise and other switchboard forms, portable forms, combination indicators and multiple switches, etc. Wheelco Instruments Co., 1933 So. Halsted St., Chicago, Ill.

E415 "Sensitive Temperature Controls for Science and Industry" is title of 12-page $8\frac{1}{2}$" × 11" catalog of precision thermoregulators and relays. H-B Instrument Co., Inc., 2500 N. Broad St., Philadelphia, Pa.

E416 Generator Voltage Regulators. 4-page $8\frac{1}{2}$" × 11" bulletin describes new vibrating type regulator for installations subject to large load fluctuations. Ideal Commutator Dresser Co., Sycamore, Ill.

E417 Optical Pyrometers. 6-page $8\frac{1}{2}$" × 11" Catalog No. 90 describes the new "Bi-optical" and the new "Micro-optical" pyrometers said to present the solution of the emissivity problem. Pyrometer Instrument Co., 103-05 Lafayette St., New York, N. Y.

E418 "Baldwin-Southwark." The November issue of this 24-page $8\frac{1}{2}$" × 11" house organ features articles on tropical Diesels, bushing press, sponge iron, etc. Baldwin-Southwark Corp., Philadelphia, Pa.

E419 "Brush Strokes." The November issue of this 12-page pocket-size house organ contains an engineering article on the "Transfilter" and on microphone uses. Brush Development Co., 3322 Perkins Ave., Cleveland, Ohio.

E420 Polarizing Microscope Attachment. $8\frac{1}{2}$" × 11" leaflet describes units which convert a standard microscope into a polarizing instrument; also the "Labscope," a self-contained polarizing strain tester. Polarizing Instrument Co., 8 West 40 St., New York, N. Y.

E421 "The Oscillographer." October-November issue of this 4-page 6" × $9\frac{1}{2}$" house organ features a technical article on materials testing with the oscillograph, also describes new television tubes and a pre-recording oscillograph. Allen B. Du Mont Laboratories, Inc., 532 Valley Rd., Upper Montclair, N. J.

E422 Pyrometers. 25" × 19" broadside folding to $9\frac{1}{2}$" × $6\frac{1}{4}$", dramatically presents a line of special vibration-proof indicating pyrometers for automotive and aircraft laboratories and instrument-board equipment. Lewis Engineering Co., Naugatuck, Conn.

E423 "B & L Instrument Bulletin." Issue No. 25 of this $8\frac{1}{2}$" × 11" mimeographed house organ features microscope equipment for dust investigation. Bausch & Lomb Optical Co., 615 St. Paul St., Rochester, N. Y.

E424 "Chemical and Biological Laboratory Instruments" is the title of a 100-page book describing maker's latest developments. Available without charge if requested on business stationery. American Instrument Co., Silver Spring, Md.

E425 TAG Manual for Inspectors of Petroleum. Edited by R. L. Wilhelm. Cloth bound, $5\frac{1}{4}$" × $7\frac{3}{4}$", 143 pages. This 24th edition of a handbook which has won for itself a unique place in oil laboratories throughout the world describes every accepted test for every petroleum product and contains numerous useful tables. New material includes revisions of Test Numbers 5, 7, 9, 11, 14, and of three tables. Sent free when requested on the letterhead of your laboratory. C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.

E426 Steam-plant Instrumentation. 32-page $7\frac{3}{4}$" × $10\frac{1}{2}$" Catalog N-33-163 covers steam-plant temperature measurements from boiler furnace to turbine, shows where temperatures are taken, explains methods of measurement, describes operation of indicating, recording and controlling equipment, illustrates instruments suitable for steam-plant use. Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.

E427 Demagnetizing Equipment, etc. Three $8\frac{1}{2}$" × 11" circulars describe electric etchers, demagnetizing and spot welders. R. B. Annis Co., Indianapolis, Ind.

E428 "More Modern Laboratory Appliances" is title of 90-page $7\frac{1}{4}$" × $10\frac{1}{2}$" catalog supplement to Fisher's 1050-page book of laboratory apparatus. It is available free of charge to laboratories. Fisher Scientific Co., Pittsburgh, Pa.

E429 Portable Brinell. Broadside folding to envelope size describes portable hardness testing equipment originally designed for inspecting rail welds on right-of-way. Teleweld, Inc., Railway Exchange Bldg., 80 E. Jackson Blvd., Chicago, Ill.

E430 Steam Traps. 30-page $8\frac{1}{2}$" × 11" "Sarco Hook-up Book" is an innovation in the steam trapping field, containing at least 75% technical material mostly in the form of diagrams. Sarco Co., 183 Madison Ave., New York, N. Y.

E431 Recording Voltmeters and Ammeters. Recent improvements in Bristol's recording voltmeters and ammeters are outlined; sample chart records are included; facts are given regarding applications in public utilities, chemical, ceramics, rubber and plastics, pulp and paper, food, and dairy. The Bristol Company, Waterbury, Conn.

E432 Counting and Registering Instruments. New condensed bulletin, folding to envelope size, describes line of stroke counters, revolution counters, lumber meters, lineal registering instruments, can & bottle counters, and "specials." Durant Mfg. Co. 1925 N. Buffum St., Milwaukee, Wis.

E433 "The General Radio Experimenter." The November issue of this 8-page 6" × 9" house organ features a technical article on a radio-frequency source for the laboratory, also describes a new adjustable attenuator. General Radio Co., 30 State St., Cambridge A, Mass.

E434 Temperature Control. Single sheet $8\frac{1}{2}$" × 11" Bulletin RS-1 describes new remote temperature resetting systems for the H & B All-Range temperature controller. B. O. Bushnell, 541 N. Kings Rd., Los Angeles, Calif.

E435 Polaroid and Polarized Light. 16-page $5\frac{1}{2}$" × $8\frac{1}{2}$" booklet gives details of new polarizing medium and basic principles of its correct application. Priced at fifty cents but available without charge to INSTRUMENTS subscribers. The Polarizing Instrument Co., 8 West 40 St., New York, N. Y.

E436 CO_2 Meters. Single sheet 9" × 12" leaflet on combustion efficiency through metering CO_2 in the boiler room. The Hays Corp., Box 299, Michigan City, Ind.

E437 Automatic Timers. A binder of six $8\frac{1}{2}$" × 11" sheets covers maker's line of portable and built-in timers and describes their correct applications for numerous purposes. Walser Automatic Timer Co., Graybar Bldg., New York, N. Y.

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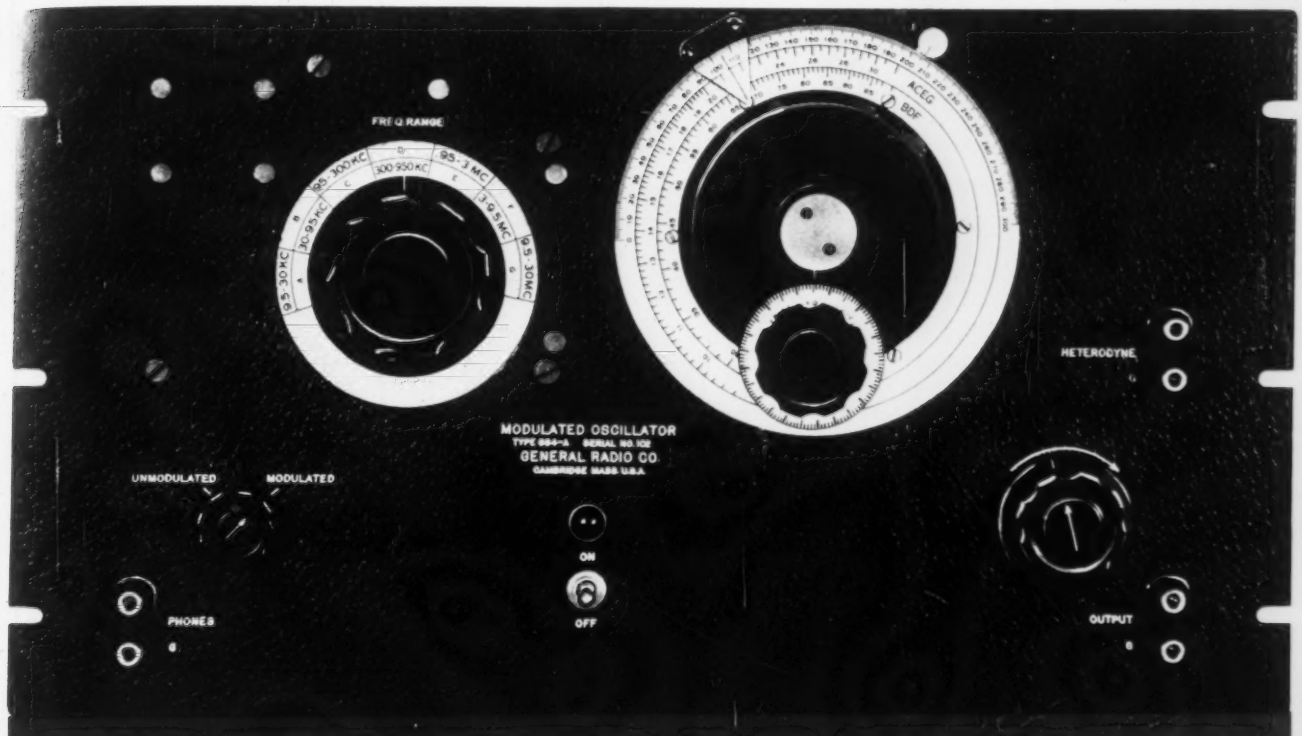

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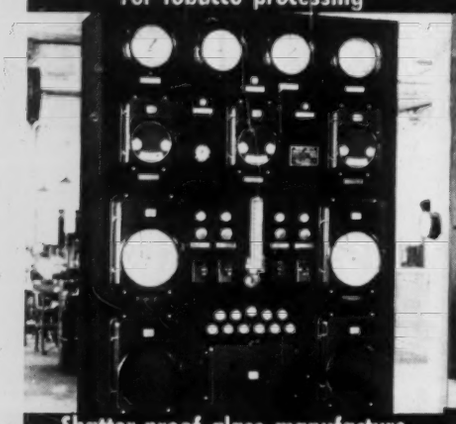
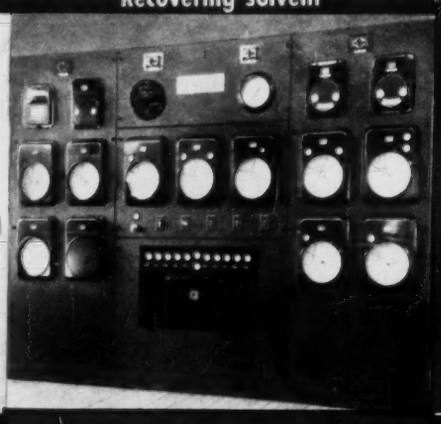


Recovering solvent



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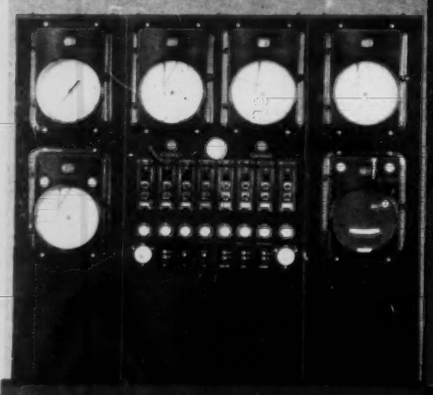
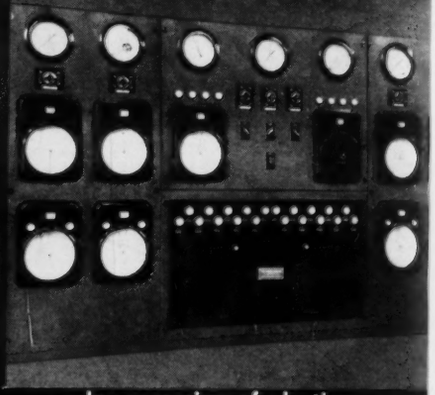


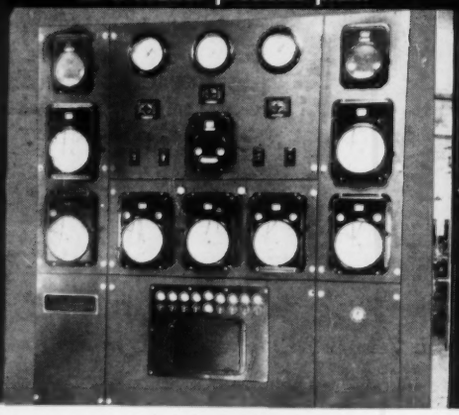
"SHORTENING TIME of process from 168 hours to ½ hour!"

Process control in chemical plant

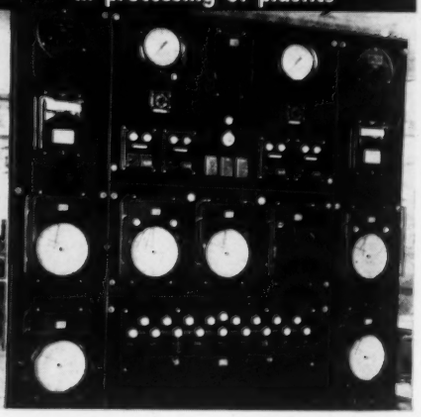


"STEPPING UP production 100%"

In a rubber products plant



In processing of plastics



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